SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. MDWG participants to provide Martin Green with PSSE crash work around.

2. SPP Staff (Sunny) to reach out to SPP RA-PCA group to see if TPL automation scripts can be provided.

3. SPP Staff (Shahrokh, Zach, & Sunny) to review dynamic schedule for PSSE 34.7 testing impacts

4. SPP Staff (Michael) to post MDWG manual version 4.0

5. SPP Staff (Kimberly) to look at ways of breaking down participation level within the report card.
Motions:

1. Jordan Lamb motioned to approve the agenda as shown on the screen. Alex Mucha seconded the motion. The motion passed unanimously.

2. Andy Berg motioned to approve the meeting minutes as amended. Jordan Lamb seconded the motion. The motion passed unanimously.

3. Jason Shook motioned to approve the June 11, 2020 meeting minutes. Nate Morris seconded the motion. The motion passed unanimously.

4. Jason Shook motioned to accept staff’s recommendation for Jerad Ethridge to fill the mid-term Chair vacancy. Steve Hohman seconded the motion. The motion passed with all in favor and one abstention by Nate Morris.

5. Holli Krizek motioned to approve the MDWG model quality assurance section and language. Jason Shook seconded the motion. The motion passed unanimously.

6. Scott Rainbolt motioned to approve the MOD matrix changes as shown on the screen. Scott Schichtl seconded the motion. The motion passed unanimously.
AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

SPP MDWG Interim Chair, Jerad Ethridge, called the meeting to order at 9:02 am with Quorum. SPP Staff Secretary, Sunny Raheem, read the anti-trust statement to the group. Sunny reminded the group the meeting is in muted mode and will require users to press “*6” to unmute if someone would like to speak.
AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES

The following members attended or were represented by proxy:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Present</th>
<th>Company</th>
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</thead>
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**MDWG MINUTES**  
**July 9, 2020**

Additional Guests:

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<td>Calvin Coates</td>
<td>Kansas City Board of Public Utilities</td>
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<td>John Payne</td>
<td>Kansas Electric Power Cooperative</td>
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<tr>
<td>Edin Terzic, <a href="mailto:Esun@les.com">Esun@les.com</a></td>
<td>Lincoln Electric System</td>
</tr>
<tr>
<td>Ryan Benton</td>
<td>Midwest Energy</td>
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<td>Brian Brownlow, Jason Menke</td>
<td>Nebraska Public Power District</td>
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AGENDA ITEM 1E – AGENDA REVIEW (APPROVAL ITEM)

Jerad Ethridge asked the group if they had a chance to review the agenda and if the group has any modifications to the agenda. The group did not voice any additional modifications.

**Motion:** Jordan Lamb motioned to approve the agenda as shown on the screen. Alex Mucha seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: JUL09_Attach1 - 1e. MDWG Meeting Agenda 20200709.docx

Jerad asked the group for any comments about the delivery of meeting materials. The group did not voice any concerns.

AGENDA ITEM 1F – PREVIOUS JUNE 3, 2020 MEETING MINUTES (APPROVAL ITEM)

Jerad Ethridge asked the group if they had any proposed changes for the previous June 3, 2020 meeting minutes and materials. A clarification redline was proposed on page 8 of the meeting minutes. Sunny Raheem redline the proposed clarification in the meeting minutes.

**Motion:** Andy Berg motioned to approve the meeting minutes as amended. Jordan Lamb seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: JUL09_Attach2 - 1f. Previous June 3, 2020 Meeting Minutes.pdf

AGENDA ITEM 1G – PREVIOUS JUNE 11, 2020 MEETING MINUTES (APPROVAL ITEM)

Jerad Ethridge asked the group if they had any proposed changes for the previous June 11, 2020 meeting minutes and materials. The group did not voice any additional modifications.

**Motion:** Jason Shook motioned to approve the June 11, 2020 meeting minutes. Nate Morris seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: Jul09_Attach3 - MDWG Minutes June 03, 2020-redline.docx
AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Sunny Raheem presented the red font updates to the action items. Michael Odom have an update for the MISO short circuit effort. Staff updated the action item for action item 32 during the meeting to provide more information. The group discussed the need for MISO to help SPP staff with assistance for mapping buses to the MMWG models. The group did not voice any additional concerns.

Material: JUL09_Attach4 - 2. MDWG_Action_Items_07022020.xlsx

AGENDA ITEM 3 – ITP QUARTERLY REPORT

Dara Solomon presented the ITP Quarterly Report about 2020, 2021, and 2022 ITP and SPP interregional studies status updates. A question was raised about the filing date for the cost and use agreement with AECI. Neil Robertson clarified the agreement is not finalized and is still pending a structured schedule but he anticipates the agreement to provide executed in the next few weeks.

The group requested clarification on the original and updated approval dates for 2021 ITP powerflow model development and load generator review. Jerad Ethridge clarified he wanted to know why the models were delayed in efforts of continuing on time delivery of models. Michael Odom mentioned there were some model updates provided at the last minute that were addressed in the delayed posting. Nate Morris mentioned that SPP met the updated deadline; however, 2020 MPM model updates needed to be processed and reviewed. Sunny Raheem then commented that there were a lot of overlapping member update deadlines for 2020 and 2021 ITP (2020 series MDWG). TWG, MDWG, and ESWG chairs and SPP management agreed to stagger the deadlines in order to allow sufficient member time for review. Eddie Watson mentioned that he agreed with Jerad’s and Sunny’s comments. Jeremy Harris thanked staff for considering member review time. Jeremy Harris then asked about how model comparisons are conducted. Staff responded that model comparisons are performed throughout the passes but would be open to any improvements. Michael and Eddie mentioned that the internal Model Validation Task Force (MVTF) should help with the review. Jeremy suggested the data handoff for the model comparisons could be a good candidate for future improvements.
AGENDA ITEM 4 – TASK FORCE/FOCUS GROUP UPDATES

AGENDA ITEM 4A – MDWG POWERFLOW FOCUS GROUP

Jeremy Harris and Moses Rotich provided a brief update for the recent MDWG Powerflow Focus Group activities including dynamic load task force update for CMLD modeling, topics review and prioritization, 2021 series model build data coordination workbook review, automation updates, Model on Demand updates, generator capability curves and introduction to Distributed Energy Resources (DER).

AGENDA ITEM 4B – MDWG DISPATCH FOCUS GROUP

Steve Hohman gave an update on the last MDWG dispatch focus group meeting on June 26. Steve mentioned the group continued good discussion about how to improve the dispatch method and how to make passes more efficient in terms of dispatching. The group discussed what firm service looks like in a compliance and super BA way. The group continues discussions about ECDI, operational bid data overview, PROMOD data review, and data transparency. Steve mentioned each approach has its own unique challenges and the generic data seems to have the least amount of transparency issues at this time. Jered Ethridge mentioned the importance of the dispatch group and encouraged members to attend group meetings.
AGENDA ITEM 5 – 2021 MDWG POWERFLOW & SHORT CIRCUIT MODEL BUILD UPDATE

Moses Rotich provided a brief update on the 2021 MDWG powerflow and short circuit model build. Moses reminded the group the model build started July 6 and EDST updates to address some reported bugs were implemented on July 1. Moses mentioned staff is working on some cleanup efforts for EDST and MOD data and then start on the pass 0 trial 1 cases. Martin Green asked if there are any known issues with slider files in PSSE v34.5. Charles Aleman responded that he had encountered a similar issue and received a fix for the issue that he will share with the group. Chris Colson mentioned the release notes require a specific range of graphic driver versions.

Moses commented that that staff intended to have solvable models next week. Moses mentioned the model build schedule has been posted and the manual will be posted by the end of the month. The group was also reminded about the August 3 deadline for max fault exceptions list for the 2021 series MDWG short circuit models. Moses mentioned to the group the GMD data request will be part of the powerflow and short circuit updates and schedules.

**Action Item:** MDWG participants to provide Martin Green with PSSE crash work around.

AGENDA ITEM 6 – 2020 MDWG / 2021 TPL DYNAMIC MODEL BUILD UPDATE

Shahrokh Akhlaghi presented the 2020 MDWG/2021 TPL dynamic model build update. Steve Hohman asked if the TP automation scripts could be available like they have been in the past. Sunny Raheem mentioned he would have to check with the Reliability Assurance Planning Coordinator Assessment group since they own the scripts. Steve Hohman asked the group how they manage different versions of PSSE. Some members of the group mentioned they could manage the major versions of PSSE on one machine but require a virtual machine to isolate and maintain multiple subversion (i.e. PSSE version 34.6.1 and 34.7.0). Sunny Raheem mentioned staff could review the schedule to see if v34.7 testing can be included in the current build.

Reené Miranda asked how the GO follow up process work when models do not initialize correctly. Sunny mentioned that SPP reaches out the GO to request review and an updated version of the model. The entity is marked late if they are not able to provide the data by the deadline.

**Action Item:** SPP Staff (Sunny) to reach out to SPP RA-PCA group to see if TPL automation scripts can be provided.

**Action Item:** SPP Staff (Shahrokh, Zach, & Sunny) to review dynamic schedule for PSSE 34.7 testing impacts
AGENDA ITEM 7 – BREAK

The group took a 10 minute break.

AGENDA ITEM 8 – EDST 2.5 RELEASE DETAILS

Kimberly presented a presentation on the latest EDST 2.5.0 release date scheduled for July 1, 2020 for enhancements and fixes. The group did not have any questions at this time.

AGENDA ITEM 9 – TOTAL MODEL REDUCTION EFFORT DISCUSSION

The total model reduction discussion was tabled for the next meeting due to time limitations.

AGENDA ITEM 10 – MDWG CHAIR NOMINATION REVIEW & APPOINTMENT (APPROVAL ITEM)

Sunny Raheem presented the nomination he received for MDWG Chair since the last meeting. Sunny mentioned that in addition to the nomination provided, Staff supports the nomination and recommends Jerad Ethridge as MDWG Chair to fill the mid-term vacancy. Sunny mentioned Jerad has participated in the MDWG for an extensive number of years and has led various efforts/groups within the MDWG. Jerad has been integral in the development of the MDWG Manual effort, the recently formed PF Focus Group, and has proven his knowledge of the material and ongoing efforts, but has also proven his ability to lead a group.

Motion: Jason Shook motioned to accept staff’s recommendation for Jerad Ethridge to fill the mid-term Chair vacancy. Steve Hohman seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed with all in favor and one abstention by Nate Morris.

Nate Morris’ abstention reasoning: “I fully support Mr. Ethridge moving into the role as Chair and endorse not only his abilities in modeling efforts but also his leadership abilities. Mr. Ethridge is an excellent selection and the nomination form exhibits as such. In an effort to avoid any appearance of a conflict of interest, paired with my installation as previous Chair of the MDWG, I abstained from the motion. “

AGENDA ITEM 11 – MDWG MEMBERSHIP UPDATE

Jered Ethridge mentioned MDWG received several nominations for membership. Dustin Betz (NPPD) was selected as the newest member of MDWG.
AGENDA ITEM 12 – MDWG MANUAL LANGUAGE

AGENDA ITEM 12A – MDWG MODEL QUALITY ASSURANCE (APPROVAL ITEM)

Michael Odom discussed the MDWG Manual Language approval for Model Quality Assurance, which included language that Data Owners are expected to ensure their data is correct before submitting to SPP. Data corrections or additions by MDWG or SPP staff is considered the last resort and will follow the SPP quarterly MOPC reporting process along with an escalation process for late data. A member of the group mentioned the escalation process should consider MOD-032-1 R3 in this process and reference any SPP OATT language that might help to improve the model build participation, and data accuracy.

Motion: Holli Krizek motioned to approve the MDWG model quality assurance section and language. Jason Shook seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: JUL09_Attach5 - 12. SPP Model Development Procedure Manual 2020 v4.0 July 9 2020_Pending_Updated.docx

AGENDA ITEM 12B – UPDATED MOD MATRIX (APPROVAL ITEM)

Michael presented the updated MOD matrix materials. Scott Rainbolt assisted in providing the background and summary of MDWG manual task force activities for the requested change. The group did not voice any concerns about the MOD matrix change.

Motion: Scott Rainbolt motioned to approve the MOD matrix changes as shown on the screen. Scott Schichtl seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: JUL09_Attach5 - 12. SPP Model Development Procedure Manual 2020 v4.0 July 9 2020_Pending_Updated.docx
Action Item: SPP Staff (Michael) to post MDWG manual version 4.0

Action Item: SPP Staff (Kimberly) to look at ways of breaking down participation level within the report card.

AGENDA ITEM 12 – SUMMARY OF ACTION ITEMS

6. MDWG participants to provide Martin Green with PSSE crash work around.

7. SPP Staff (Sunny) to reach out to SPP RA-PCA group to see if TPL automation scripts can be provided.

8. SPP Staff (Shahrokh, Zach, & Sunny) to review dynamic schedule for PSSE 34.7 testing impacts

9. SPP Staff (Michael) to post MDWG manual version 4.0

10. SPP Staff (Kimberly) to look at ways of breaking down participation level within the report card.

AGENDA ITEM 12 – DISCUSSION OF FUTURE MEETINGS

Jerad Ethridge outlined the future MDWG, MDWG workshop, MDWG focus groups, and MDWG manual task force meetings.

AGENDA ITEM 7 – ADJOURN (APPROVAL ITEM)

Jerad Ethridge adjourned the meeting at 12:06 pm (CDT).

Respectfully Submitted,

Sunny Raheem

Secretary
Attachments

Material: JUL09_Attach1 - 1e. MDWG Meeting Agenda 20200709.docx

Material: JUL09_Attach2 - 1f. Previous June 3, 2020 Meeting Minutes.pdf

Material: Jul09_Attach3 - MDWG Minutes June 03, 2020-redline.docx

Material: JUL09_Attach4 - 2. MDWG_Action_Items_07022020.xlsx

Material: JUL09_Attach5 - 12. SPP Model Development Procedure Manual 2020 v4.0 July 9 2020_PENDING_UPDATED.docx
AGENDA

1. Administrative Items ................................................................. Jerad Ethridge (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous June 3, 2020 Meeting Minutes (Approval Item)
   g. Previous June 11, 2020 Meeting Minutes (Approval Item)

2. Review of Past Action Items .................................................. Sunny Raheem (5 mins)

3. ITP Quarterly Report ............................................................... Dara Solomon (15 mins)

4. Task Force/Focus Group Updates:
   a. MDWG Powerflow Focus Group ......................... Jeremy Harris/Moses Rotich (5 mins)
   b. MDWG Model Dispatch Group ......................... Steve Hohman/Lottie Richardson (5 mins)

5. 2021 MDWG Powerflow & Short Circuit Model Build Update .... Moses Rotich (15 mins)

6. 2020 MDWG / 2021 TPL Dynamic Model Build Update ............ Shahrokh Akhlaghi (10 mins)

7. Break ................................................................................................................. (5 mins)

8. EDST 2.5 Release Details ...................................................... Kimberly Woods (15 mins)

9. Total Model Reduction Effort Discussion ..................... Sunny Raheem/Moses Rotich (30 mins)

10. MDWG Chair Nomination Review & Appointment (Approval Item) ... Sunny Raheem (5 mins)

11. MDWG Membership Update ......................................................... Jerad Ethridge (5 mins)

12. MDWG Manual Language
   a. MDWG Model Quality Assurance (Approval Item) ............... Michael Odom (20 mins)
b. Updated MOD Matrix *(Approval Item)* ........................................Michael Odom (20 mins)

13. Summary of Action Items.................................................................................................................... Sunny Raheem (5 mins)

14. Discussion of Future Meetings............................................................................................................. Jerad Ethridge (10 mins)

   a. **MDWG:**

      i. August 13, 2020 Conference Call (9:00AM – 12:00PM)

      ii. September 10, 2020 Conference Call (9:00AM – 12:00PM)

      iii. Virtual Workshop August 18 – 19 (8:30AM – 4:00PM)

   b. **Manual Task Force:**

      i. July 16, 2020 (10:00AM–12:00PM)

      ii. July 23, 2020 (10:00AM–12:00PM)

   c. **Focus Groups Meetings:**

      i. **Power Flow:**


         2. August 24, 2020 (9:30AM – 11:30AM)

      ii. **Short Circuit:**

         1. August 11, 2020 (9:00AM – 11:00AM)

         2. November, 17, 2020 (9:00AM – 11:00AM)

      iii. **Dynamics:**

         1. July 22, 2020 (10:00AM – 12:00PM)

         2. October 21, 2020 (10:00AM – 12:00PM)

      iv. **Generation Dispatch:**

         1. July 30, 2020 (2:00PM – 4:00PM)

15. Adjourn.................................................................................................................................................... All

* The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. SPP to post approved 2021 MDWG/2022 ITP model build schedule in both pdf and excel format

2. Moses to send out an email to Data Submitters for feedback on things that need to be tested (powerflow, short circuit and dynamics, GMD, etc) before moving to a new version of PSSE. The feedback will then be discussed at a future powerflow focus group meeting

3. Manual task force to review the data coordination language and bring back to the MDWG if still warranted

Motions:

1. Jason Shook made the motion to approve the agenda as modified. Jordan Lamb seconded it. There was no discussion on the motion and it passed unanimously.

2. Scott Schichtl made the motion to approve the previous meeting minutes. Andy Berg seconded it. There was no discussion on the motion and it passed unanimously.

3. John Boshears made the motion to approve the node-breaker modeling language as presented. Holli Krizek seconded it. There was no discussion on the motion and it passed unanimously.
AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

SPP MDWG Chair, Nate Morris, called the meeting to order at 1:07 p.m. with Quorum. SPP Staff Secretary, Moses Rotich, read the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES

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<td>Edin Terzic, <a href="mailto:Esun@les.com">Esun@les.com</a></td>
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<tr>
<td>Brianna Haug, Gayle Nansel, Chris Colson</td>
<td>Western Area Power Administration</td>
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AGENDA ITEM 1E – AGENDA REVIEW *(APPROVAL ITEM)*

Nate Morris asked the group whether they had any modifications to the agenda. No one proposed changes to the agenda.

**Motion:** Jason Shook made the motion to approve the agenda as modified. Jordan Lamb seconded it. There was no discussion on the motion and it passed unanimously.

Material: JUNE03_Attach1 - 1e. MDWG Meeting Agenda 20200603.docx

Nate asked whether the group had any comments on the availability and deliverability of meeting material. He noted that as far as he was concerned, the material was posted on time.

AGENDA ITEM 1F – PREVIOUS MAY 13 MEETING MINUTES *(APPROVAL ITEM)*

Nate Morris asked the group whether they had any proposed changes for the previous meeting minutes. There were no comments.

**Motion:** Scott Schichtl made the motion to approve the previous meeting minutes. Andy Berg seconded it. There was no discussion on the motion and it passed unanimously.

Material: JUNE03_Attach2 - 1f. May 13 2020 MDWG Meeting Minutes.pdf
AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Moses gave a summary of certain action items:

- Action Item 31 - reach out to MISO modeling for bus mapping data for short circuit model build. *(In progress)*
- Action Item 69 – justification for branch impedance to be discussed in SCFG *(in progress)*
- Action Item 83 – update from Brooke and Michael, updates were made in retirement workbook and added comments field *(complete)*
- Action Item- staff to send representation to MOPC *(complete)*
- Action Item 89- send email to group regarding manual language approval *(complete)*

For action item 89, Jerad asked if the manual had been posted already or whether staff was waiting on more updates. Michael said that the newest version will be posted once all updates have been made to the manual.

AGENDA ITEM 3 – TASK FORCE/FOCUS GROUP UPDATES

AGENDA ITEM 3A – MDWG POWERFLOW FOCUS GROUP

Moses Rotich gave an update on the group’s activities. He highlighted the following items that were discussed at the last powerflow focus group meetings:

- Discussed PSSE version to determine which version utilize between PSSE v34.7 and v34.8. The group recommended using PSSE v34.7 in the 2021 series model build.
- Discussed model build schedule approved by SPP management and took some feedback
- Discussed draft node-breaker language before taking it to the MDWG manual task force for further discussion. He noted that this language was an approval item in the meeting and would be covered later in the agenda.
- Discussed the MMWG language change on the definition of the light load model and addition of the minimum load models. After much deliberation at the powerflow focus group meeting, the group decided on not changing the SPP definition of light load.
- Future meetings starting in July will be changed to once a month
AGENDA ITEM 3B – MDWG DYNAMIC FOCUS GROUP

Shahrokh gave an update. He said the group meetings now occur every 3 months but in the last one, they discussed DERs and ESRs and proposed language that was sent to the manual task force. He also noted that Marc Moor had resigned as chair of the group and that they were seeking a volunteer to chair it. Nate then urged those interested in chairing the group to reach out to him or Jerad.

AGENDA ITEM 3C – MDWG GENERATION DISPATCH FOCUS GROUP

Steve gave an update on the group's activities. He highlighted some of the issues being evaluated by the group:

- TPL-001 requirement for known commitments
- Input data sources and ease of sharing that data
- NITSA interpretation by SPP
- Staff investigating sharing of ABB data.....licenses Vs NDAs
- Shortfall process under proposed super BA dispatch approach
- Roadmap for finalizing assumptions and benchmarking new dispatch

AGENDA ITEM 3D – MDWG SHORT CIRCUIT FOCUS GROUP

Michael gave an update on the group’s activities. He noted that they had discussed DERs/ESRs and are working on getting some companies to present on ESRs in future meetings. He noted that the next SCFG call is on August 11th, 2020.

AGENDA ITEM 4 – ITP GEN/LOAD DATA DEPENDENCIES FROM MDWG SCHEDULE DEADLINES

Brooke gave an educational session on the ITP gen and load review and its dependencies on the MDWG schedule. During discussion, Andy Berg asked about the 2 resource plans, “Are they just informational platforms to perform futures for the ITP or is there more to it?” Brooke answered that resource plan generation is not included in the base reliability models. They are intended for transmission planning studies. She said the resource adequacy standards help determine how much generation to include in the economic models. Michael also added that the table on slide 6 is all in the context of ITP models and doesn't affect attachment AA.
Chris Colson then made a comment germane to the MDWG; economic load and gen review might be done by different people in the same company and same data can be submitted to SPP in a different ways such as Pmax/Pmin values that can be different for the economic models as opposed to the powerflow models. Brooke then mentioned that generation capacities for gen review are initially populated by vendor data so model builders need to review and update this information accordingly.
MDWG MINUTES
June 3, 2020

AGENDA ITEM 5 – 2021 MDWG / 2022 ITP ACTIVITIES

AGENDA ITEM 5A – SCHEDULE REVIEW

Moses presented an overview of the schedule. He went through the presentation before pulling up the schedule in excel format. He noted the major milestones and deadlines on the schedule, the MOD and PSSE versions to be utilized for the upcoming model build series, and the inclusion of updates based on lessons learned from the previous model build. He then mentioned that there was a thorough SPP internal review of the schedule to make sure that it aligned with some of the other processes that have dependencies on the data being collected through the powerflow models. He also noted the last chance to submit certain kinds of data updates in order to avoid impacting other process milestones and encouraged all Data Submitters to do their best to meet these deadlines. After the presentation, Moses solicited feedback from the group on the schedule and noted that the schedule will be presented as an approval meeting in the June 11, 2020 MDWG meeting. Several minor improvements were proposed by the group such as: addition of MOD and PSSE versions, font/color code consistency, calendar (.ics) version of schedule, addition of ITP finalization for consistency and posting of both a pdf and excel version of the schedule for easy filtering.

**Action Item:** SPP to post approved 2021 MDWG/2022 ITP model build schedule in both pdf and excel format

Chris Colson then commented that he wanted to bring up one more the need to possibly consider PSSE version 35. He said that they had downloaded PSSE v35.1 yesterday and had done some benchmarking against v34.7 (powerflow and short circuit) but hadn’t done any dynamics testing. As an end-user, he noted that PSSE v34.7 will not be useable for GMD studies based on some updates in v35.1. John Turner then commented that it would be good if SPP can make a script that details differences between two PSSE versions and bring results before the MDWG. Eddie Watson also commented that SPP had reviewed PSSE v35 but might not be looking to move to it at this time.

**Action Item:** Moses to send out an email to Data Submitters for feedback on things that need to be tested (powerflow, short circuit and dynamics, GMD, etc) before moving to a new version of PSSE. The feedback will then be discussed at a future powerflow focus group meeting.

AGENDA ITEM 5A – MODEL SELECTION REVIEW

Michael Odom presented. There were no questions after this presentation.

AGENDA ITEM 6 – BREAK
AGENDA ITEM 7 – MDWG MANUAL LANGUAGE

AGENDA ITEM 7A – DATA COORDINATION (APPROVAL ITEM)

Michael presented on this item. Jerad Ethridge commented that if a GO sent data to SPP, the interconnecting TO would also be copied on it. He then added that it is always good to keep TOs informed of impacting changes going into the models. After some further deliberation, Nate solicited a motion but no one was willing to make one. As such, Nate asked the manual task force to review this language again.

**Action Item:** Manual task force to review the data coordination language and bring back to the MDWG if still warranted.

AGENDA ITEM 7B – NODE BREAKER (APPROVAL ITEM)

Michael Odom presented on this language. Nate asked whether any in the manual task force or powerflow focus group had any comments both in support or disagreement of the language. Jeremy commented that ratings A, B and C in other sections need to be updated to the new PSSE v34 ratings. Michael noted that this will be done in the next MDWG meeting.

**Motion:** John Boshears made the motion to approve the node-breaker modeling language as presented. Holli Krizek seconded it. There was no discussion on the motion and it passed unanimously.

Material: JUNE03_Attach2 - 7. SPP Model Development Procedure Manual 2020 v4.0 June 2020_Pending.docx

AGENDA ITEM 8 – MDWG LEADERSHIP UPDATE

Nate gave an update on MDWG leadership. He said that he would step down as chair effective after this meeting and thanked the group for their camaraderie and support. He said that the vice chair, Jerad Ethridge, would take over until the chair is officially voted. He hoped that as he stepped down, he was leaving the group in a better place than when he took over. Eddie then took a moment to thank Nate for his leadership to the group and SPP staff. Sunny also took some time from his vacation to thank Nate for his leadership and leading the group to a state where the models have been posted on time for the past 3 years. He also commented that he looked forward to working with Jerad. Jerad then thanked Nate for making the group enjoyable. He also noted that Nate had wanted to mention this in-person but because of COVID-19, he wasn’t able to. Eddie then extended an invitation for Nate to show up to the next MDWG face-face meeting whenever travel resumes again and face-face meetings are able to be held.
Not allowing to be outdone, and close to tears, Scott Rainbolt thanked Nate for his leadership as well and voiced support for Jerad. He thanked Nate for steadying the ship and making sure that models are posted on time.
AGENDA ITEM 9 – SUMMARY OF ACTION ITEMS

Moses summarized the action items captured during the meeting:

1. SPP to post approved 2021 MDWG/2022 ITP model build schedule in both pdf and excel format

2. Moses to send out an email to Data Submitters for feedback on things that need to be tested (powerflow, short circuit and dynamics, GMD, etc) before moving to a new version of PSSE. The feedback will then be discussed at a future powerflow focus group meeting

3. Manual task force to review the data coordination language and bring back to the MDWG if still warranted
AGENDA ITEM 10 – DISCUSSION OF FUTURE MEETINGS

Nate asked whether the MDWG workshop meeting in August is still scheduled as an in-person meeting or webex. Sunny answered that since SPP will lift its travel ban around August 1st, the meeting would most likely be a webex.

AGENDA ITEM 11 – ADJOURN

Nate Morris adjourned the meeting at 4:00 pm (CDT).

Respectfully Submitted,

Moses Rotich
Secretary
Attachments
JUNE03_Attach1 - 1e. MDWG Meeting Agenda 20200603.docx

JUNE03_Attach2 - 1f. May 13 2020 MDWG Meeting Minutes.pdf

JUNE03_Attach3 - 7. SPP Model Development Procedure Manual 2020 v4.0 June 2020_Pending.docx
AGENDA

1. Administrative Items ................................................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous May 13, 2020 Meeting Minutes (Approval Item)
2. Review of Past Action Items .................................................................................... Moses Rotich (5 mins)
3. Task Force/Focus Group Updates:
   a. MDWG Powerflow Focus Group ................................................................. Jeremy Harris/Moses Rotich (10 mins)
   b. MDWG Dynamics Focus Group ................................................................. Shahrokh Akhlaghi (10 mins)
   c. MDWG Model Dispatch Group ................................................................. Steve Hohman/Lottie Richardson (10 mins)
4. ITP Gen/Load Data Dependencies from MDWG Schedule Deadlines....Brooke Keene (20 mins)
5. 2021 MDWG / 2022 ITP Activities:
   a. Schedule Review ......................................................................................... Moses Rotich (30 mins)
   b. Model Selection Review ............................................................................. Michael Odom (30 mins)
6. Break .......................................................................................................................... (10 mins)
7. MDWG Manual Language:
   a. Data Coordination (Approval Item*) ......................................................... Michael Odom (20 mins)
   b. Node Breaker (Approval Item*) ................................................................. Michael Odom (20 mins)
8. MDWG Leadership Update ..................................................................................... Nate Morris (5 mins)
9. Summary of Action Items ......................................................................................... Moses Rotich (5 mins)
10. Discussion of Future Meetings

   a. **MDWG:**
      i. June 11, 2020 Conference Call (9:00AM – 12:00PM)
      ii. July 9, 2020 Conference Call (9:00AM – 12:00PM)
      iii. GO Education Session Conference Call June 17, 2020 (1:00PM – 4:00PM)
      iv. MDWG Workshop August 18 – 19, 2020 (8:30AM – 4:00PM) - SPP Campus (Tentative)/WebEx (Confirmed)

   b. **Manual Task Force:**
      i. June 4, 2020 (10:00AM-12:00PM)
      ii. June 18, 2020 (10:00AM-12:00PM)

   c. **Focus Groups Meetings:**
      i. **Power Flow:**
         1. June 1, 2020 (9:30AM – 11:30AM)
         2. June 15, 2020 (9:30AM – 11:30AM)
      ii. **Short Circuit:**
         1. August 11, 2020 (9:00AM – 11:00AM)
         2. November, 17, 2020 (9:00AM – 11:00AM)
      iii. **Dynamics:**
         1. July 22, 2020 (10:00AM – 12:00PM)
         2. October 21, 2020 (10:00AM – 12:00PM)
      iv. **Generation Dispatch:**
         1. May 27, 2020 (2:00PM – 4:00PM)
         2. June 26, 2020 (2:00PM – 4:00PM)

   d. **Dynamic Load Task Force:** TBD

11. Adjourn

* The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. Staff (Sunny Raheem) send MDWG representation solicitation to SPP MOPC contacts after the MDWG meeting.

2. Staff (Sunny Raheem) to send email to the group about manual language approval and February 13, 2020 meeting minutes changes for approval in order to solicit a motion by Friday.

Motions:

1. Jason Shook motioned to adopt the agenda as modified. Scott Schichtl seconded the motion. The motion passed unanimously.

2. Jason Shook motioned to adopt the April 16 meeting minutes as modified. Jerad Ethridge seconded the motion. The motion passed unanimously.

3. Email Vote Results
   
   - MINS Language approved motion: Steve Hohman motioned to approve the MINS language changes as posted in the May 13, 2020 MDWG conference call background materials. Jason Shook seconded the motion. The motion passed unanimously.

   - February 13, 2020 Addendum Motion: Andy Berg motioned to approve the February 13, 2020 meeting minute addendum to replace the previous February 13, 2020 meeting minutes. Scott Rainbolt seconded the motion. The motion passed unanimously.
**MDWG MINUTES**  
May 13, 2020

**SOUTHWEST POWER POOL**  
MODEL DEVELOPMENT WORKING GROUP MEETING

May 13, 2020 9:00 am – 12:00 pm (CST)  
Conference Call

**MINUTES**

**AGENDA ITEM 1 – ADMINISTRATIVE ITEMS**

**AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT**

SPP MDWG Chair, Nate Morris, called the meeting to order at 9:05 am with Quorum. SPP Staff Secretary, Sunny Raheem, read the anti-trust statement to the group.

**AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES**

The following members attended or represented by proxy:

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<th>Proxy</th>
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<td>Jerad Ethridge</td>
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<td>Joe Fultz</td>
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<td>Jordan Lamb</td>
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<td>Reené Miranda</td>
<td>YES</td>
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<td>Alex Mucha</td>
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<td>Sunny Raheem</td>
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<td>Southwest Power Pool, Inc., MDWG Secretary</td>
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Additional Guests:

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<td>Josh Hesselbein</td>
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AGENDA ITEM 1E – AGENDA REVIEW

Nate Morris asked the group if they had a chance to review the agenda and if the group has any modifications to the agenda. Sunny Raheem mentioned staff recently added a GO modeling workshop to the list of meetings in June that was scheduled after posting of background materials. The group did not voice any additional modifications.

**Motion: Jason Shook motioned to adopt the agenda as modified. Scott Schichtl seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.**

Material: MAY13_Attach1 - 1e. MDWG Meeting Agenda 20200513_redline

Nate asked the group for any comments about the delivery of meeting materials. The group did not voice any concerns. Nate thanked Sunny Raheem and staff for posting materials in a timely manner.

AGENDA ITEM 1F – PREVIOUS APRIL 16 MEETING MINUTES

Nate Morris asked the group if they had any proposed changes for the previous meeting minutes and materials. Moses Rotich provided a clarification language to an action item. Jeremy Harris provided a correction to a typo in meeting minutes under agenda item 4a.

**Motion: Jason Shook motioned to adopt the April 16 meeting minutes as modified. Jerad Ethridge seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.**

Material: MAY13_Attach2 - 1f. Previous April 16, 2020 Meeting Minutes_redline.pdf

AGENDA ITEM 1G – 2020 PSSE USER GROUP MEETING REMINDER

Nate Morris presented the 2020 PSSE UGM reminder to the group. Nate highlighted the different meeting categories that Siemens will present. At the request of Nate, Sunny Raheem displayed the 2020 PSSE UGM email registration and requirements. Sunny noted the UGM might be particularly helpful for new graduate hires to learn about PSSE.
AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Sunny Raheem presented the red font updates to the action items. Sunny thanked the focus groups for addressing the action items for doing a great job. Nate mentioned the MISO short circuit data request action item has a July update assigned to it from the previous MDWG meeting discussion. The group did not voice any additional concerns.

AGENDA ITEM 3 – FOCUS GROUP UPDATES

AGENDA ITEM 3A – MDWG POWERFLOW FOCUS GROUP

Jeremy Harris reminded the group of the MDWG Powerflow Focus Group’s (PFFG) scope and purpose. Jeremy Harris provided the group about recent MDWG PFFG activities including SPP EMS modeling process and rating submission updates, node breaker modeling discussions, and future agenda topics. The group discussed if equipment ratings are being considered in PFFG discussions. Jeremy mentioned there are several equipment ratings discussions and what should be included as part of the branch ratings. Reené Miranda asked if short circuit rating inclusion is a possibility in the latest PSSE 34 version. Jeremy mentioned the short circuit ratings is in the PSSE ideas portal but not available in the current PSSE version. Reené voiced concern about including several ratings and the data management involved.

AGENDA ITEM 3B – MDWG DYNAMIC FOCUS GROUP

At a later meeting time than originally scheduled, Shahrokh Akhlaghi provided an update on recent MDWG Dynamic Focus Group activities including the SPP IBIS PLL information review, 2020 series dynamic model update, node breaker modeling, and contingency definitions, and electrical storage resource modeling requirements. Shahrokh mentioned the group is moving to quarterly meetings. Sunny Raheem informed the group that Marc Moor will be stepping down as the leader of the dynamic focus group due to other activities. Sunny solicited for interest in leading the group. Nate Morris added there would be great support from staff in that role. Nate and Sunny thanked Marc for advancing the focus group. Eddie mentioned he appreciated Marc’s efforts and involvement along with all other members’ involvement in the focus groups.

AGENDA ITEM 3C – MDWG GENERATION DISPATCH FOCUS GROUP

Steve Hohman provided an update on the recent MDGW Generation Dispatch Focus Group meeting. Steve mentioned it was a good meeting with a lot of discussions. Staff presented an ECDI priority vs PROMOD stack order review. As the next steps, staff is going to look at the comparison of the actual PROMO data vs EDCI dispatch. Joe Fultz mentioned the presentations at the last meeting were excellent are available for interested parties.
AGENDA ITEM 3D – MDWG SHORT CIRCUIT FOCUS GROUP

Reené Miranda provided an update on recent MDWG Short Circuit Focus Group activities and discussion from the meeting the day before. Reené mentioned the group discussed DER modeling and MISO coordination data. The group talked about way measure improvement in the SPP-MISO short circuit data collection. Sunny Raheem mentioned that the SPP engineering modeling group has started bi-weekly coordination calls with MISO to understand their process. Sunny mentioned the short circuit data exchange was a topic as the previous meeting. Sunny mentioned that Michael Odom would provide an update on a future MDWG meeting.

Andy Berg mentioned the ESR steering committee at SPP and how some items might be brought from TWG to MDWG. Michael mentioned one of the items assigned to TWG is ESR modeling which will probably be assigned by TWG to MDWG. Staff reminded the group the current ESR and DER MDWG language development will assist in completing some parts of the ESR steering committee and HITT task. Eddie Watson commented that there is a project currently at SPP to incorporate ESRs and DERs into models with consideration of best practices from other RTOs and guidance from NERC.

AGENDA ITEM 3E – DYNAMIC LOAD TASK FORCE

Scott Jordan provided an update on the composite load model work the Dynamic Load Task Force has been doing. Scott thanked the stakeholders for engagement in the group’s activities. Scott mentioned the group is now comfortable with the residential composite load models so far. However, is some concern in the group about motor D stalling.

AGENDA ITEM 4 – MDWG MEMBERSHIP UPDATE

Nate Morris updated the group that Jason Hofer has resigned from his MDWG voting seat due to taking another position at NPPD. Nate mentioned staff would be sending out the membership nomination solicitation to SPP MOPC representations soon. Nate encouraged the group without an MDWG representative to work with their MOPC representative for nomination.

Action Item: Staff (Sunny Raheem) send MDWG representation solicitation to SPP MOPC contacts after the MDWG meeting.
AGENDA ITEM 5 – SIEMENS PTI PSSE VERSION 35 RELEASE UPDATE

Amar Patel introduced himself to the group and presented the Siemens PTI PSSE version 35 overview. Amar provided the group how major releases are developed, how releases are classified, key benefits of PSSE version 35, and why users should have confidence in the version 35 models including MMWG case testing. Amar solicited for test scripts. The group discussed the scope of test scripts. Amar clarified that he would be looking for scripts that interact with PSSE. Reené Miranda mentioned that his organization has rigorous testing for software. The testing has to be completed before he can move to a new version of PSSE. Nate Morris thanked Amar for coming to the MDWG and presenting an update.

AGENDA ITEM 6 – RISK-BASED PLANNING

Chris Jamieson updated the group on recent risk-based planning activities. The recent activities update includes the EPRI case study and MOPC action items. Chris reviewed the overall continuous improvement initiatives for the transmission adequacy assessments. Chris mentioned the goals and objectives along with the schedules.

AGENDA ITEM 7 – 2020 SERIES MDWG DYNAMIC MODEL BUILD UPDATE

Shahrokh Akhlaghi provided the group a summary of completed, in-progress, and future tasks as part of the 2020 series MDWG dynamic model build update. Shahrokh mentioned the MMWG models finalized recently in mid-May with the originally anticipated date of February. Shahrokh mentioned that staff is trying to identify ways to stay on track and right now believes the project will stay on schedule even with the MMWG delay.

AGENDA ITEM 8 – BREAK

The group did not take a break
AGENDA ITEM 9 – 2021 MDWG / 2022 ITP ACTIVITIES

AGENDA ITEM 9A – PSSE/MOD VERSION DISCUSSION

Moses Rotich presented a comparison of features between PSSE version 34 and 35. Additionally, Moses presented a comparison between MOD 10 and 11.

Nate Morris asked the group and staff about their thoughts about moving PSSE versions. Moses Rotich and Sunny Raheem mentioned they personally support the move to PSSE version 35 but understand the hesitation of moving to a new version. Scott Jordan mentioned he would recommend dynamic model testing be performed before moving to the new version. Sunny explained since the move to NERC acceptable models, the testing should be easier than past years. The issue will be the user-written models that are not able to convert to the new PSSE version. Chris Colson mentioned modeling is one test but results in the comparison is another test. Chris mentioned the GIC module has been going through some large changes in each release, which can cause compliance issues when the software is not performing as expected. Liam Stringham commented that his company has hardware locks and is not able to move to PSSE v35 at this time without exchanging hardware locks with Siemens PTI before the upcoming model build.

Nate mentioned to the group that the other items on the agenda would have to be tabled for the next meeting. Nate asked staff if any approvals could be facilitated via email approval. Sunny Raheem mentioned the MDWG MINs language. Nate Morris mentioned he received revisions to the February 13, 2020 meeting minutes as brought up by Western Area Power Administration.

**Action Item: Staff (Sunny Raheem) to send email to the group about manual language approval and February 13, 2020 meeting minutes changes for approval in order to solicit a motion by Friday.**
Email Vote Results

- **MINS Language approved**
  - Motion: Steve Hohman motioned to approve the MINS language changes as posted in the May 13, 2020 MDWG conference call background materials. Jason Shook seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.
  - Material: MAY13_Attach3 - 10. SPP Model Development Procedure Manual 2020 v4.0 May 2020_Pending.docx

- **February 13, 2020 Addendum**
  - Motion: Andy Berg motioned to approve the February 13, 2020 meeting minute addendum to replace the previous February 13, 2020 meeting minutes. Scott Rainbolt seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.
  - Material: MAY13_Attach4 - MDWG Minutes Feb 13 2020 Addendum.docx

AGENDA ITEM 9B – SCHEDULE STATUS UPDATE
Tabled for a future meeting

AGENDA ITEM 9C – MODEL SELECTION REVIEW & NEXT STEPS
Tabled for a future meeting. Sunny Raheem reminded the group about the member usage survey request due by May 22, 2020.

AGENDA ITEM 10 – MDWG MANUAL LANGUAGE

AGENDA ITEM 10A – MINS LANGUAGE (**APPROVAL ITEM***)
Review and approval via email voting protocols

AGENDA ITEM 10B – DATA COORDINATION (**APPROVAL ITEM***)
Tabled for a future meeting
AGENDA ITEM 11 – SUMMARY OF ACTION ITEMS

1. Staff (Sunny Raheem) send MDWG representation solicitation to SPP MOPC contacts after the MDWG meeting.

2. Staff (Sunny Raheem) to send email to the group about manual language approval and February 13, 2020 meeting minutes changes for approval in order to solicit a motion by Friday.

AGENDA ITEM 12 – DISCUSSION OF FUTURE MEETINGS

Nate Morris outlined the future MDWG, MDWG workshop, MDWG focus groups, and MDWG manual task force meetings. Jerad Ethridge commented and correct the June MDWG meeting is on the June 11, 2020 and not June 13, 2020.

AGENDA ITEM 7 – ADJOURN (APPROVAL ITEM)

Nate Morris adjourned the meeting at 12:13 pm (CDT).

Respectfully Submitted,

Sunny Raheem

Secretary
Attachments

MAY13_Attach1 - 1e. MDWG Meeting Agenda 20200513_redline

MAY13_Attach2 - 1f. Previous April 16, 2020 Meeting Minutes_redline.pdf

MAY13_Attach3 - 10. SPP Model Development Procedure Manual 2020 v4.0 May 2020_Pending.docx

MAY13_Attach4 - MDWG Minutes Feb 13 2020 Addendum.docx
AGENDA

1. Administrative Items ........................................................................................................Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous April 16, 2020 Meeting Minutes (Approval Item)
   g. 2020 PSSE User Group Meeting Reminder

2. Review of Past Action Items ............................................................................................Sunny Raheem (5 mins)

3. Task Force/Focus Group Updates:
   a. MDWG Powerflow Focus Group ....................... Jeremy Harris/Moses Rotich (10 mins)
   b. MDWG Dynamics Focus Group ....................... Marc Moor/Shahrokh Akhlaghi (5 mins)
   c. MDWG Model Dispatch Group ....................... Steve Hohman/Lottie Richardson (5 mins)
   d. MDWG Short Circuit Focus Group ...................... Reené Miranda/Michael Odom (5 mins)
   e. Dynamic Load Task Force ......................................................... Scott Jordan (5 mins)

4. MDWG Membership Update ..............................................................................................Nate Morris (5 mins)

5. Siemens PTI PSSE Version 35 Release Update ........................................................................Amar Patel (25 mins)

6. Risk-Based Planning ...........................................................................................................Chris Jamieson (15 mins)

7. 2020 series MDWG Dynamic Model Build Update ........ Shahrokh Akhlaghi/Zach Sabey (5 mins)

8. Break ........................................................................................................................................(10 mins)

9. 2021 MDWG / 2022 ITP Activities:
   a. PSSE/MOD Version Discussion ................................................................................All (10 mins)

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
b. Schedule Status Update ........................................ Moses Rotich/David Duhart (15 mins)
c. Model Selection Review & Next Steps ......................... Michael Odom (30 mins)

10. MDWG Manual Language:
   a. MINS language (*Approval Item*) ................................................................. (10 mins)
   b. Data Coordination (*Approval Item*)............................................................... (25 mins)

11. Summary of Action Items ................................................................. Sunny Raheem (5 mins)

12. Discussion of Future Meetings ............................................................. Nate Morris (10 mins)
   a. MDWG:
      i. May/June TBD June 3, 2020 Conference Call (19:00APM – 124:00PM)
      ii. June 4311, 2020 Conference Call (9:00AM – 12:00PM)
      iii. Workshop Tentatively Schedule for August 18 – 19 (8:30AM – 4:00PM) at SPP Campus
      iv. June 17, 2020 GO Education Session Conference Call (1:00PM – 4:00PM)
   b. Manual Task Force:
      i. May 7, 2020 (10:00AM-12:00PM)
      ii. May 21, 2020 (10:00AM-12:00PM)
   c. Focus Groups Meetings:
      i. Power Flow:
         1. May 18, 2020 (9:30AM – 11:30AM)
         2. June 1, 2020 (9:30AM – 11:30AM)
      ii. Short Circuit:
         1. May 12, 2020 (9:00AM – 11:00AM)
         2. August 11, 2020 (9:00AM – 11:00AM)
      iii. Dynamics:
         1. May 20, 2020 (10:00AM – 12:00PM)
         2. July 22, 2020 (10:00AM – 12:00PM)
      iv. Generation Dispatch:
         1. May 7, 2020 (2:00PM – 4:00PM)
         2. May 27, 2020 (2:00PM – 4:00PM)
   d. Dynamic Load Task Force: May 6, 2020 (1:30PM – 3:30PM)

13. Adjourn ........................................................................................................ All

**Antitrust:** SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
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* The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. Staff (Moses & Sunny) to reach out to SPP EMS modeling staff to see if an EMS education session can be provided.

2. Staff (Lottie) to provide the full EDST enhancement list to the group.

3. MDWG Manual Task Force to review the GMD modeling section and update it to match the latest template.
MDWG MINUTES
April 16, 2020

Motions:

1. Jordan Lamb motioned to adopt the agenda as modified on the screen. Jason Shook seconded the motion. The motion passed unanimously.

2. Jason Shook move to approve the March 19, 2020 meeting minutes. Andy Berg seconded the motion. The motion passed unanimously.

3. Jerad Ethridge motions to approve the March 27, 2020 meeting minutes. Jeremy Harris seconded the motion. The motion passed unanimously.

4. Reené Miranda motions to approve the shunt modeling language displayed on the screen. Jeremy Harris seconded the motion. The motion passed unanimously.

5. Andy Berg motions to approve the GMD language presented on the screen. Jordan Lamb seconded the motion. The motion passed unanimously.

6. Jason Shook to approve the aux load language and table as in the background material. Jerad Etheridge seconded the motion. The motion passed unanimously.

7. Jason Shook to approve relay model language for relay model language items 1 and 2 and only the voltage and frequency relay models as shown in the table. Reené Miranda seconded the motion. The motion passed unanimously.

8. Reené Miranda motioned to adjourn the meeting. Jerad Ethridge seconded the motion. The motion passed unanimously.
AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

SPP MDWG Chair, Nate Morris, called the meeting to order at 9:04 am with Quorum. SPP Staff Secretary, Sunny Raheem, read the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES

The following members attended or represented by proxy:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nate Morris</td>
<td>YES</td>
<td>Proxy</td>
<td>Empire District Electric Company, MDWG Chair</td>
</tr>
<tr>
<td>Jerad Ethridge</td>
<td>YES</td>
<td></td>
<td>Oklahoma Gas &amp; Electric, MDWG Vice-Chair</td>
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<td>Charles Aleman</td>
<td>YES</td>
<td></td>
<td>Golden Spread Electric Cooperative</td>
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<td>Andrew Berg</td>
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<td>Missouri River Energy Services</td>
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<td>Preston Blinsky</td>
<td>YES</td>
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<td>Basin Electric Power Cooperative</td>
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<td>John Boshears</td>
<td>YES</td>
<td></td>
<td>City Utilities of Springfield</td>
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<tr>
<td>Joe Fultz</td>
<td>YES</td>
<td></td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Jeremy Harris</td>
<td>YES</td>
<td></td>
<td>KCP&amp;L and Westar, Every Companies</td>
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<tr>
<td>Jason Hofer</td>
<td>YES</td>
<td></td>
<td>Nebraska Public Power District</td>
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<tr>
<td>Steve Hohman</td>
<td>NO</td>
<td>John Mayhan</td>
<td>YES</td>
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<tr>
<td>Holli Krizek</td>
<td>YES</td>
<td></td>
<td>Western Area Power Administration</td>
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<tr>
<td>Jordan Lamb</td>
<td>YES</td>
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<td>East River Electric Power Cooperative</td>
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<td>Reené Miranda</td>
<td>YES</td>
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<td>Southwestern Public Service</td>
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<tr>
<td>Alex Mucha</td>
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<td>Oklahoma Municipal Power Authority</td>
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<tr>
<td>Scott Rainbolt</td>
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<td>American Electric Power</td>
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<td>Scott Schichtl</td>
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<td>Arkansas Electric Cooperative Company</td>
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<tr>
<td>Jason Shook</td>
<td>YES</td>
<td></td>
<td>GDS Associates</td>
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<tr>
<td>Liam Stringham</td>
<td>YES</td>
<td></td>
<td>Sunflower Electric Power Corporation</td>
</tr>
<tr>
<td>Sunny Raheem</td>
<td>YES</td>
<td></td>
<td>Southwest Power Pool, Inc., MDWG Secretary</td>
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## Additional Guests:

<table>
<thead>
<tr>
<th>Guests</th>
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<tbody>
<tr>
<td>Josh Hesselbein</td>
<td>Arkansas Electric Cooperative Corporation</td>
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<tr>
<td>David Zhong, Martin Green</td>
<td>American Electric Power</td>
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<tr>
<td>Jeremy Severson</td>
<td>Basen Electric Power Cooperative</td>
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<td>Calvin Coates</td>
<td>BPU</td>
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<tr>
<td>Conner Sweet, Jerry Bradshaw</td>
<td>City Utilities of Springfield</td>
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<tr>
<td>Tyler Baxter</td>
<td>Corn Belt Power Cooperative</td>
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<tr>
<td>Jeff Crites</td>
<td>Empire District Electric Company</td>
</tr>
<tr>
<td>Matthew Keenan</td>
<td>Enel</td>
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<tr>
<td>Lafayette Gatewood, Marc Moor, Pallab Datta, Rob Bouda, Ryan Baysinger</td>
<td>Evergy Companies</td>
</tr>
<tr>
<td>Diego Toledo, Dona Parks</td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Michael Wegner</td>
<td>Golden Spread Electric Cooperative</td>
</tr>
<tr>
<td>John Payne</td>
<td>Kansas Electric Power Coop</td>
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<tr>
<td>Edin Terzic</td>
<td>Lincoln Electric System</td>
</tr>
<tr>
<td>John Weber</td>
<td>Missouri River Energy Services</td>
</tr>
<tr>
<td>Armin Sehic</td>
<td>Municipal Energy Agency of Nebraska</td>
</tr>
<tr>
<td>John Mayhan, Tom Mayhan</td>
<td>Omaha Public Power District</td>
</tr>
<tr>
<td>Becca McCann, Brooke Keene, Charlton Hill, Eddie Watson, Kimberly Woods, Lottie Richardson, Michael Odom, Moses Rotich, Shahrokh Akhlaghi, Shannon Mickens, Zach Sabey</td>
<td>Southwest Power Pool, Inc.</td>
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<tr>
<td>Dave Sargent</td>
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<td>Aravind Chellappa, Frank Favela</td>
<td>Southwestern Public Service</td>
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<td>Tanner New</td>
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<td>Hummad Malhi, Joe Williams, Josh Turner</td>
<td>Western Farmers Electric Cooperative</td>
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<tr>
<td>Ben Hammer, Brianna Haug, Chris Colson, Jeffrey Anderson</td>
<td>Western Area Power Administration</td>
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AGENDA ITEM 1E – AGENDA REVIEW

Nate Morris asked the group if they had a chance to review the agenda and if the group has any modifications to the agenda. Sunny Raheem mentioned the MDWG Generation Dispatch Focus Group meeting moved to May 7. Sunny mentioned the May 13 meeting was previously scheduled to be a face-to-face meeting but is now a shortened conference call. The group talked about the possible need for an additional meeting. The group, in general, agreed to have multiple shortened conference calls vs a daylong conference call meeting. The group did not voice any additional modifications.

Jordan Lamb motioned to adopt the agenda as modified on the screen. Jason Shook seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: APR16_Attach1 - 1e. MDWG Meeting Agenda 20200416_redline.docx

Nate asked the group if they had any concerns about the delivery of background materials. The group did not voice any concerns.

AGENDA ITEM 1F – MARCH 19 MEETING MEETINGS

Nate Morris asked the group if they had any modification to the March 19, 2020 meeting minutes. There was no additional discussion or feedback to the minutes from the group.

Motion: Jason Shook move to approve the March 19, 2020 meeting minutes. Andy Berg seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: APR16_Attach2 - 1f. Previous March 19, 2020 Meeting Minutes.pdf

AGENDA ITEM 1G – MARCH 27 MEETING MEETINGS

Nate Morris asked the group if they had any modification to the March 27, 2020 meeting minutes. There was no additional discussion or feedback to the minutes from the group.

Motion: Jerad Ethridge motions to approve the March 27, 2020 meeting minutes. Jeremy Harris seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: APR16_Attach3 - 1g. Previous March 27, 2020 Meeting Minutes.pdf
AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Sunny Raheem presented an overview of the action items and briefly discussed recently completed items. Sunny reviewed staffs’ comments as denoted in red font since the last meeting for in-progress action items. The group talked at length about action item 31. The group discussed actionable next steps with MISO to get the short circuit data. Michael Odom mentioned he has been working with MISO to get the data. Michael mentioned he can provide an update to the action item in June/July for feedback based on the data request process. Michael updated the group on MISO’s future efforts of collecting short circuit data which should help SPP with its short circuit collection from external data owners. Sunny Raheem mentioned SPP modeling staff is working on a monthly coordination call with MISO to assistance with the education of each other’s model build process and data sharing.

AGENDA ITEM 3 – 2019 SERIES MOD-033-1 VALIDATION INTRODUCTION

Becca McCann introduced herself to the group. Becca described her responsibilities with the modeling group since she joined. Becca presented MOD-033-1 standard review, the 2019 series MOD-033-1 powerflow validation, and the status of the project. The group discussed the issues and challenges from the last iteration of the MOD-033-1 validation including unacceptable differences in real and reactive powerflow flows in particular along the SPP seams. Sunny Raheem mentioned that one of the improvements implemented this time around is to put boundary conditions that match the EMS tie-line flows at the far end should help with the discrepancy. The group asked about the actual time of the 2019 August EMS Summer Peak timing. Sunny mentioned it was at 4:39pm on August 19, 2019. Becca McCann described the pre-validation step for Transmission Owners to participate in if they would like. The pre-validation step would include a voluntary review of the mapping assumptions and impedance differences. Chris Colson provided his support for the MOD-033-1 to improve the MOD-032-1 model build. The group discussed if the comparison EMS case would be posted with the pre-validation planning case. Sunny mentioned SPP would post it in support of the MOD-033-1 effort.

The group expressed interest in knowing how the EMS models are updated and how ratings are handled in the commercial model. The group discussed if SPP has a FAC-008 schedule for updates. Sunny mentioned he is not aware of a schedule for updating ratings, however, the models are updated monthly and ratings are providing continuously. Chris Colson pointed to the SPP operational rating submission tool.

Action Item: Staff (Moses & Sunny) to reach out to SPP EMS modeling staff to see if an EMS education session can be provided.
AGENDA ITEM 4 – MDWG FOCUS GROUP

AGENDA ITEM 4A – POWERFLOW FOCUS GROUP

Jeremy Harris provided an update on recent MDWG Powerflow Focus Group activities including the 2020 series model update, shunt modeling benchmarking, and node breaker modeling. Jeremy gave kudos to Moses Rotich for posting materials and keeping up to date on action items. The group talked about the recommendation for node-breaker data scope for 345kV and higher for the 2021 series model build and then expanding to 230kV in the 2022 series model build. Jeremy Harris put a plug in to encourage members to get their new hires involved in the powerflow focus group.

AGENDA ITEM 4B – MODEL DISPATCH FOCUS GROUP

Lottie Richardson gave an update for the dispatch focus group recent activities including a work plan overview for Super BA vs step-by-step approach. The focus group conducted a Doodle poll to see the preference from the group for the approach going forward. Based on the Doodle poll, members wanted to focus on the Super BA approach going forward. Lottie mentioned that staff has been meeting with other RTOs to understand their dispatch process to be presented at an upcoming MDWG Model Dispatch Focus Group meeting.

AGENDA ITEM 5 – EDST UPDATES

AGENDA ITEM 5A – MEMBER ENHANCEMENT POLL RESULTS

Lottie Richardson thanked Kimberly Woods for the work she did as part of the recent EDST enhancement and requests follow up. Lottie introduced Kimberly Woods to the group. Lottie walked the group through the EDST member feedback Doodle Poll responses. The group reviewed the top three items listed in the presentation. Members of the group asked about the other items that do not make the list. Sunny Raheem mentioned they are still on the enhancement list. The group discussed how the enhancement list is review. Sunny mentioned he would like to see the list reviewed every year. The group reviewed the Doodle Poll participation level in detail. The group asked if the poll limited organizations to one response and the scope of the audience requested to respond. Staff commented that it was not restricted to one response per organization. Future EDST enhancements can consider that. The group asked for the full enhancement list to be shared.

Action Item: Staff (Lottie) to provide the full EDST enhancement list to the group.
AGENDA ITEM 5 – MDWG MANUAL

Michael Odom highlighted the approval items for shunt modeling, GMD, aux load, and MINS language.

AGENDA ITEM 5A – SHUNT MODELING LANGUAGE (APPROVAL ITEM*)

Michael presented the shunt modeling language updates to the group. The group reviewed the language and supplemental benchmarking results that the MDWG Powerflow Focus Group developed and reviewed. The group noted the increase in voltage violations a decrease in non-convergence results. The group discussed if the language address modeling of in-line reactors. The group commented the modeling assumption changes that will need to take place with modeling in-line reactors in node-breaker models. The group discussed the impacts of in-line modeling on the GMD assessment.

Motion: Reené Miranda motions to approve the shunt modeling language displayed on the screen. Jeremy Harris seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

AGENDA ITEM 5B – GMD LANGUAGE (APPROVAL ITEM*)

Michael presented the GMD language updates to the group. During the group review, OPPD mentioned the GMD language does not match well with the template, which could lead to confusion for someone reviewing the information and template for the first time. Chris Colson mentioned that the language does not necessarily speak to the data input but provides a scope for the data requested. John Mayhan mentioned folks could be confused when they look at the GMD shunt language. Some members of the group agreed with the language is a good start and having language drafted is better than no language.
Motion: Andy Berg motions to approve the GMD language presented on the screen. Jordan Lamb seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Action Item: MDWG Manual Task Force to review the GMD modeling section and update it to match the latest template.

AGENDA ITEM 5C – AUX LOAD LANGUAGE (APPROVAL ITEM*)

Michael presented the Aux load modeling language updates to the group. The group reviewed the language. The group discussed if there is a floor such as 1MW for aux loads to be modeled. Staff commented there is no set floor for modeling aux loads. Some members mentioned they do not model very small aux load explicitly in the models.

Motion: Jason Shook to approve the aux load language and table as in the background material. Jerad Etheridge seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

AGENDA ITEM 5D – MINS LANGUAGE (APPROVAL ITEM*)

Michael presented the MINs modeling language updates to the group. Michael mentioned the updates to the language since the last MDWG meeting. The group discussed if all four relay models should be included in the table as the language above it only addresses two. Staff suggested removing the relays not address by the language and working with the MDWG Manual Task Force to add the missing language.

Motion: Jason Shook to approve relay model language for relay model language items 1 and 2 and only the voltage and frequency relay models as shown in the table. Reené Miranda seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: APR16_Attach4 - 6. SPP Model Development Procedure Manual 2020 v4.0 Mar 2020_Pending_Updated.docx

AGENDA ITEM 5E – PLAN FOR 2021 SERIES MANUAL LANGUAGE DEVELOPMENT

Agenda Item 5E tabled for a future meeting
AGENDA ITEM 8 – STANDARDS UPDATE

Due to the meeting closing time approaching, Shannon Mickens quickly presented the NERC standards update. Shannon updated the group on items from the NERC Planning Committee and NERC Standards Committee meetings. Shannon highlighted the Reliability Guideline for DER Data Collection, MOD-032-1 SAR drafting team nomination, and NERC Transmission Connected Resources SAR nomination. A person in the group asked if SPP could share their MOD-032-1 SAR drafting team nomination. Sunny Raheem mentioned he would feel more comfortable sharing in offline.

AGENDA ITEM 9 – SUMMARY OF ACTION ITEMS

1. Staff (Moses & Sunny) to reach out to SPP EMS modeling staff to see if an EMS education session can be provided.
2. Staff (Lottie) to provide the full EDST enhancement list to the group.
3. MDWG Manual Task Force to review the GMD modeling section and update it to match the latest template.

AGENDA ITEM 10 – DISCUSSION OF FUTURE MEETINGS

Nate Morris outlined the future MDWG, MDWG focus groups, and MDWG manual task force meetings.

AGENDA ITEM 7 – ADJOURN (APPROVAL ITEM)

Nate Morris asked the group if they had any other topics for discussion before the group adjourned. Nate mentioned the recent MOPC reviewed Robert’s Rule for adjourning the meeting, which might be practiced at the next meeting. The group did not voice any additional topics.

Motion: Reené Miranda motioned to adjourn the meeting. Jerad Ethridge seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at 12:30 pm (CDT).

Respectfully Submitted,

Sunny Raheem

MDWG Secretary
Attachments

APR16_Attach1 - 1e. MDWG Meeting Agenda 20200416_redline.docx

APR16_Attach2 - 1f. Previous March 19, 2020 Meeting Minutes.pdf

APR16_Attach3 - 1g. Previous March 27, 2020 Meeting Minutes.pdf

APR16_Attach4 - 6. SPP Model Development Procedure Manual 2020 v4.0 Mar 2020_Pending_Updated.docx
AGENDA

1. Administrative Items......................................................................................................Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous March 19, 2020 Meeting Minutes (Approval Item)
   g. Previous March 27, 2020 Meeting Minutes (Approval Item)

2. Review of Past Action Items ...................................................................................Sunny Raheem (5 mins)

3. 2019 series MOD-033-1 Validation Scope Introduction .................................Becca McCann (20 mins)

4. MDWG Task Force/Focus Group Updates:
   a. Powerflow Focus Group.........................Jeremy Harris/Moses Rotich (15 mins)
   b. Model Dispatch Group.........................Steve Hohman/Lottie Richardson (10 mins)

5. EDST Updates
   a. Member Enhancement Poll Results .. Lottie Richardson/Kimberly Woods (15 mins)

6. MDWG Manual
   a. Shunt Modeling Language (Approval Item*).........................Michael Odom/All (20 mins)
   b. GMD Language (Approval Item*).................................Michael Odom/All (10 mins)
   c. Aux Load Language (Approval Item*).................................Michael Odom/All (10 mins)
   d. MINS Language (Approval Item*)......................................Michael Odom/All (5 mins)

7. 2021 MDWG / 2022 ITP Model Selection Approach.................................Michael Odom (30 mins)

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
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8. Standards Update .................................................................................................................. Shannon Mickens (15 mins)

9. Summary of Action Items .................................................................................................. Sunny Raheem (5 mins)

10. Discussion of Future Meetings ......................................................................................... Nate Morris (10 mins)
    a. **MDWG**: May 7, 2020 Conference Call (9:00AM – 12:00PM)
    b. **Manual Task Force**: April 23, 2020 (10:00AM-12:00PM)
    c. **Focus Groups Meetings**:
        i. Power Flow: April 20, 2020 (9:30AM – 11:30AM)
        ii. Short Circuit: May 12, 2020 (9:00AM – 11:00AM)
        iii. Dynamics: April 22, 2020 (10:00AM – 12:00PM)
        iv. Generation Dispatch: **April 28, 2020 Reschedule to May 7** (2:00PM – 4:00PM)
    d. **Dynamic Load Task Force**: Week of April 20, 2020 (Actual date/time TBD)

11. Adjourn (**Approval Item**) .......................................................................................... All

* The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. Moses to send out an email to Data Submitters about the cutoff date for corrections

2. Moses to discuss internally with other SPP staff and MISO on the modeling of Lewis and Clark unit retirements and get back with WAPA

3. SPP to post the final models and notify Data Submitters

Motions:

1. Andy Berg made a motion to approve the agenda as presented. Jason Shook seconded it.

2. Jason Shook made a motion to approve the February 13, 2020 meeting minutes as corrected. John Boshears seconded it.

3. John Boshears made a motion to approve the 2020 MDWG Powerflow models with the expectation that all significant docude code issues (Raw Read Errors, Branch Overloads, Voltage Violations, Pgens Out of Range) are addressed. Jeremy seconded it.

4. Andy Berg made a motion to adjourn the meeting. Jeremy Harris seconded it.
MDWG MINUTES
March 19, 2020

SOUTHWEST POWER POOL
MODEL DEVELOPMENT WORKING GROUP MEETING

March 19, 2020 9:00 a.m. – 12:00 p.m. (CDT)
Conference Call

MINUTES

AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

SPP MDWG Vice-Chair, Jerad Ethridge, called the meeting to order at 9:04 a.m. with Quorum.
SPP proxy Staff Secretary, Moses Rotich, read the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES

The following members attended or represented by proxy:

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<th>Proxy</th>
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<td>Sunny Raheem</td>
<td>NO</td>
<td>Moses Rotich</td>
<td>YES</td>
<td>Southwest Power Pool, Inc., MDWG Secretary</td>
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## Additional Guests:

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<td>Josh Hesselbein</td>
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AGENDA ITEM 1E – AGENDA REVIEW

Jerad asked the group if they had a chance to review the agenda and if the group had any modifications to the agenda. The group did not voice any modifications.

**Motion:** Andy Berg made a motion to approve the agenda as presented. Jason Shook seconded it. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: MAR19_Attach1 - 1e. MDWG Meeting Agenda 20200319.docx

AGENDA ITEM 1F – PREVIOUS MEETING MINUTES

Jerad asked the group if they had any modification to the February 13, 2020 meeting minutes. Seeing no comments from the group, Jerad suggested a few minor edits to the posted minutes.

**Motion:** Jason Shook made a motion to approve the February 13, 2020 meeting minutes as corrected. John Boshears seconded it. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: MAR19_Attach2 - 1f. Previous February 13, 2020 Meeting Minutes.pdf

AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Moses presented an overview of the action items and briefly discussed the progress of certain action items. Moses reviewed staffs’ comments as denoted in red font since the last meeting for in-progress action items.

Michael Odom provided the group an update on action items 31 and 68. Michael commented that for action item 31, bus mapping from MISO will not be readily available in the 2021 series model build but that SPP will be coordinating with MISO directly in the future instead of asking for the data from MISO’s individual members. He then proceeded to ask the group whether this item could be marked as complete but some members requested that it be left in progress as a reminder until accomplished.

For action item 68, Michael commented that the Short Circuit Focus Group had discussed the item and Chris Colson had provided a write for justification, but that this action item will stay in progress until accomplished.

Material: MAR19_Attach3 - 2. MDWG_Action_Items_03122020.xlsx
AGENDA ITEM 3 – 2020 SERIES MDWG POWERFLOW MODELS (APPROVAL ITEM*)

Jerad asked Moses to present the overview for approval. Moses started the discussion by going through a background of the changes that were submitted since the deadline for submissions. He noted that there were many corrections submitted for various reasons: confusion between which updates go into project files vs profiles in MOD, EDST updates dependent on some external updates; new information received from other groups within Data Submitter companies; issue arising from MOD project committals and updating MOD base case. He then capped off the presentation by recommending that the models be approved with the caveat that significant docucode issues are addressed.

After the presentation, Jerad asked Moses to go through the red tabs in docucode to determine which tabs need to be addressed to proceed with approving the models. Moses went through each red tab of docucode and identified the tabs that still needed to be addressed for the models to be considered final. After deliberating on whether to move the approval vote to the following week or approve the models with the expectation that significant docucode errors are addressed, the MDWG decided to proceed with the latter. Jerad then suggested that corrections for significant issues be provided to SPP by Friday, March 20, 2020 9:00 am to allow SPP ample time to apply the changes before posting. As part of this discussion, Ben Hammer and Chris Colson asked that SPP consider retiring the Lewis and Clark unit that had been submitted to MISO under its attachment Y retirement process. Additionally, this retirement, also affects WAPA since it is very close to the SPP seam.

**Action Item:** Moses to send out an email to Data Submitters about the cutoff date for corrections.

**Action Item:** Moses to discuss internally with other SPP staff and MISO on the modeling of Lewis and Clark unit retirements and get back with WAPA.

After additional comments on the way forward, Jerad entertained a motion from the group.

**MOTION:** John Boshears made a motion to approve the 2020 MDWG Powerflow models with the expectation that all significant docucode issues (Raw Read Errors, Branch Overloads, Voltage Violations, Pgens Out of Range) are addressed. Jeremy seconded it. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

**Material:** MAR19_Attach4 - 3. 2020 MDWG Powerflow Update.pptx

**Action Item:** SPP to post the final models and notify Data Submitters

Jeremy Severson then asked if the models will also be posted in PSSE version 33. Moses said that staff would post the models in both PSSE version 34 and 33.
AGENDA ITEM 4 – SUMMARY OF ACTION ITEMS

1. Moses to send out an email to Data Submitters to about the cutoff date for corrections
2. Moses to discuss internally with other SPP staff and MISO on the modeling of Lewis and Clark unit retirements and get back with WAPA
3. SPP to post the final models and notify Data Submitters

AGENDA ITEM 5 – DISCUSSION OF FUTURE MEETINGS

Jerad briefly mentioned the upcoming meetings such as MDWG manual task force, focus groups and MDWG. Moses then reminded the group that Siemens will present on node breaker modeling at the 3/23/2020 PFFG call so he encouraged everyone to attend.

AGENDA ITEM 6 – ADJOURN (APPROVAL ITEM)

Jerad asked the group if they had any other topics for discussion before the group adjourned. The group did not voice any additional topics.

Motion: Andy Berg made a motion to adjourn the meeting. Jeremy Harris seconded it. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at approximately 10:48 a.m. (CDT).

Respectfully Submitted,

Moses Rotich

SPP Staff
Attachments

MAR19_Attach1 - 1e. MDWG Meeting Agenda 20200319.docx
MAR19_Attach2 - 1f. Previous February 13, 2020 Meeting Minutes.pdf
MAR19_Attach3 - 2. MDWG_Action_Items_03122020.xlsx
MAR19_Attach4 - 3. 2020 MDWG Powerflow Update.pptx
SOUTHWEST POWER POOL, INC.
MODEL DEVELOPMENT WORKING GROUP MEETING
March 19, 2020
Conference Call
9:00 a.m. – 12:00 p.m. (CDT)

AGENDA

1. Administrative Items.................................................................................................. Jerad Ethridge (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous February 13, 2020 Meeting Minutes (Approval Item)
2. Review of Past Action Items .................................................................................... Moses Rotich (5 mins)
3. 2020 series MDWG Powerflow Models (Approval Item*) .......... Moses Rotich /All (60 mins)
4. Summary of Action Items ...................................................................................... Moses Rotich (5 mins)
5. Discussion of Future Meetings** ......................................................................... Jerad Ethridge (10 mins)
   a. MDWG: March 27, 2020 Conference Call (9:00AM – 12:00PM)
   b. Manual Task Force: March 26, 2020 (10:00AM-12:00PM)
   c. Focus Groups Meetings:
      i. Power Flow: March 23, 2020 (9:30AM – 11:30AM)
      ii. Short Circuit: May 12, 2020 (9:00AM – 11:00AM)
      iii. Dynamics: April 22, 2020 (10:00AM – 12:00PM)
      iv. Generation Dispatch: March 24, 2020 (2:00PM – 4:00PM)
6. Adjourn (Approval Item).............................................................................................. All

* The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG

** Future meeting times are in central daylight savings.
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:
1. Moses to include language about aux load in the ITP models in the posting email.

Motions:
1. Jason Shook motioned to approve the agenda as presented. Steve Hohman seconded the motion.

2. Jason Shook moves to approve the January 22, 2020 meeting minutes as presented in the background meeting materials. Jerad Ethridge seconded the motion. The motion passed with one abstention.

3. Reené Miranda moves to approve the manual language for “The capability amounts for PMAX, PMIN, QMAX, QMIN should not be changed until the unit is fully decommissioned”. Scott Schichtl second. The motion passed unanimously.

4. Jason Shook motioned to adjourn the meeting. Andy Berg seconded the motion. The motion passed unanimously.
MINUTES

AGENDA ITEM 1 – ADMINISTRATIVE ITEMS
AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

SPP MDWG Chair, Nate Morris, called the meeting to order at 9:33 am with Quorum. SPP Staff Secretary, Sunny Raheem, read the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES

The following members attended or represented by proxy:

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## MDWG MINUTES
February 13, 2020

**Additional Guests:**

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AGENDA ITEM 1E – AGENDA REVIEW

Nate Morris asked the group if they had a chance to review the agenda and if the group has any modifications to the agenda. The group did not voice any modifications.

Motion: Jason Shook motioned to approve the agenda as presented. Steve Hohman seconded the motion.

Material: FEB13_Attach1 - 1e. MDWG Meeting Agenda 20200213.docx

AGENDA ITEM 1F – PREVIOUS MEETING MINUTES

Nate Morris asked the group if they had any modification to the January 22, 2020 meeting minutes. There was no additional discussion or feedback to the minutes from the group.

Motion: Jason Shook moves to approve the January 22, 2020 meeting minutes as presented in the background meeting materials. Jerad Ethridge seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed with one abstention. Reené Miranda provided the following comments for his abstention.

Reené Miranda: “Reason for my abstention of the January 22, MDWG meeting minutes is that I was not present at the meeting.”

Material: FEB13_Attach2 - 1f. Previous January 22, 2020 Meeting Minutes.pdf

AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Sunny Raheem presented an overview of the action items and briefly discussed recently completed items. Sunny reviewed staffs’ comments as denoted in red font since the last meeting for in-progress action items.

Michael Odom provided the group an update for action item 73. Michael mentioned staff identified that the short circuit data in EDST is used during the merge process of the short circuit models regardless of whether AECI submits data.

GRDA responded that this satisfies them to know that the source of data is from EDST rather than AECI. Staff suggested the action item be marked as complete. Nate mentioned that if other people have questions about the short circuit data they can reach out to Michael directly. Dona Parks from GRDA agreed the action item could be marked as complete. A member of the group asked if the powerflow data during the merge process is also from EDST. Staff confirmed both powerflow and short circuit data during the merge is honored from EDST.
Michael Odom provided an update for action item 75 pertaining to updating the manual task force meeting time and public calendar. Michael mentioned some of the task force meetings will be shifted or maybe once a month calls since some of the meetings conflict with the MDWG meetings. Michael mentioned there are many discussion topics for the MDWG manual task force for the upcoming model build.

Scott Rainbolt asked about action item 72 pertaining to SPP Staff’s response for evaluate the age and condition data collection based on the 2019 ITP constraints. Sunny Raheem answered that the modeling team has communicated the 2019 ITP constraints evaluation recommendation the SPP ITP teams. However, additional follow is required before staff can be provide an answer. Sunny mentioned there is a concern about the impact to the portfolio if an issue is uncovered. Scott recommended the action item be marked as in-progress and not completed. Staff agreed to the action item 72 status update.

AGENDA ITEM 3 – SPP DYNAMIC LOAD TASK FORCE UPDATE

Scott Jordan gave a brief update on the recent SPP Dynamic Load Task Force (DLTF) activities. Scott discussed certain breaker-breaker contingency testing on a few cases with the additional composite dynamic loads. Scott mentioned the case worked fine with the contingency analysis with the composite load models in the case. Scott mentioned the DLTF would bring some language for the MDWG manual on composite load models in the next few months.

Chris Colson commented that part of the conversation MDWG needs to be cognizant of is how MDWG will get some of the Distributed Energy Resource (DER) information. Chris urged the group to be aware that the DER information collecting effort is coming quick and some policies will have to be written.

AGENDA ITEM 4 – MDWG GENERATION DISPATCH FG UPDATE

Steve Hohman asked Lottie Richardson to summarize some of the meeting minutes from the previous generation dispatch meeting. Lottie provided a brief description of the topics from the last meeting. Chris Colson provided a summary of the “super balance area” proposal he presented at the last focus group meeting. Chris mentioned the next step is to formulate an ECDI file for all units in SPP using generic heat rate data to demonstrate that a super BA economic dispatch is a better way to approach the MDWG model dispatch.

Steve highlighted the TWG action item 186 to address model reduction was kept open. Steve mentioned the NEDTF discussions that could affect the planning model dispatch assumptions. Steve mentioned the group will discuss whether ECDI or block dispatch should be used and that the process will have to be transparent to data submitters and owners.

Lottie then encouraged everyone to join them on the generation dispatch meeting to learn and provide input. Sunny then asked Lottie to go through the draft agenda for the next focus group; Lottie stepped through some items of the items at the next meeting.
AGENDA ITEM 5 – 2020 SERIES MDWG MODEL UPDATES

AGENDA ITEM 5A – POWERFLOW

Moses Rotich provided the group an update on the 2020 series MDWG powerflow models. Moses reminded the group the EDST survey is still out for feedback and he would encourage members to participate in that effort. Moses mentioned a MOD file builder patch was communicate via email yesterday. Moses communicated the posting of the updated modeling contact spreadsheet for feedback.

Moses reminded the group of the MDWG manual Letter of Notice should be provided if a data submitter is providing data on behalf of another data owner. Reené Miranda asked if mentioned SPS is not the Transmission Planner for a Generator Owner (GO) facility. In this scenario should SPS provide data updates if SPS is aware of the GO data update. Staff mentioned they would like to be aware of the data update so SPP can follow up with the GO as part of the MOD-032-1 data submission. Andy Berg mentioned MRES as the Transmission Owner should not have to submit the data submission data Letter of Notice. Staff agreed with Andy.

WAPA asked who has access to the modeling contact spreadsheet. Staff commented that all data submitters have access to the modeling contact. The updated modeling contact spreadsheet is scheduled to be posted on February 28, 2020.

Staff mentioned the modeling contact spreadsheet has been helpful for SPP planning efforts also including the tariff studies coordination. Jonathan Hayes mentioned that SPP submitted entity contact database for NERC to house for compliance contacts. Jonathan mentioned that this would create efficiency for the industry.

Moses provided the MDWG group with an update on outstanding questions that staff received about the Pass 2 models. Moses explained an edited MOD project ratings header caused the light load rating discrepancies in Pass 2. The group discussed if there was a way to pull the ratings header information to avoid the issue in future model builds. Moses mentioned Siemens PTI would remove the headers for projects in a future release. Moses mentioned the issue with the 2025 Shoulder peak model. Additionally, Moses mentioned a small set of projects of certain type and status not applied in Pass 2. Moses mentioned staff informed the affected parties of the issue and staff will apply the missing projects in the next pass. Moses mentioned some data submitters noticed issues with the 25SH case. Moss mentioned that staff inadvertently did not apply a large set of MOD updates to this one particular case. Moses mentioned since the 25SH case does not have deliverables or requirements for the planning process outside of MMWG, staff can accommodate additional time to clean up this particular case if necessary.
MDWG MINUTES  
February 13, 2020

AGENDA ITEM 5B – SHORT CIRCUIT

Michael Odom provided the update for the 2020 series MDWG short circuit model build. Michael mentioned that staff recently received updates from Mid-American Electric for their short circuit data, which was requested by November 15, 2019. Michael mentioned staff would work with the consultant to incorporate the update. Michael mentioned the project is still on schedule for a February 28, 2020 posting pending any unforeseen issues with the models.

AGENDA ITEM 5C – DYNAMICS

Shahrokh Akhlaghi provided a quick update for the 2020 series MDWG dynamic models that just kicked off in January 2020. Shahrokh mentioned the initial data update deadline is February 21, 2020. The group did not have any questions.

AGENDA ITEM 6 – MDWG MANUAL LANGUAGE APPROVAL (APPROVAL ITEM*)

Michael Odom gave the group an update on the manual language revisions. The group reviewed changes to the generator retirement language. The group discussed how to handle mothballed units. The group reviewed the redline language for retirements. The group discussed risk of dispatching retirement units in the SPP planning processes including ITP. Staff commented that for processes such as AQ and ITP, if the unit has firm service, the units can be called upon if the Pmax and Pmin values are stated.

The group then reviewed the language about station service and aux load: Aux load should be modeled per the state of the generator. The group discussed a scenario in which the unit is online, the aux load is off, and how the modeling for those elements should be conducted. The group leaned on the language that included should instead of shall to allow for the unique modeling situations like the one that was discussed. A member commented on how their hydro loads are set with the net load of 0 regardless of the generator status. The group discussed the possibility of a 10MWs cutoff for aux load. Some members in the group mentioned that TWG might be having similar discussions. The group discussed how the aux loads are handled in the ITP models. Staff mentioned the ITP Base Reliability aux loads are set through MOD similar to the MDWG models. Evergy commented that they model both a variable and fixed aux load amounts for all their owned units.

**Action Item:** Moses to include language about aux load in the ITP models in the posting email.

The group reviewed the relay section of the manual language changes. Michael Odom mentioned the relay section language was reviewed by the MDWG Dynamic Focus Group and then the Manual Task Force. The group discussed the need for standardizing the models instance number (MINs). Jason Shook asked if the language is requesting additional models to be provided then what is typically already provided. Sunny Raheem commented that he would expect the voltage and frequency relay models to be provided to show the actual response of
the units. Some members of the group agreed the language might be requesting more models then what is currently provided. The group agreed to have the manual task force to discuss the relay language further.

Nate asked the group how they would like to proceed with the approvals. The group suggested they would like to break out the approvals into manual language sections.

Motion: Reené Miranda moves to approve the manual language for “The capability amounts for PMAX, PMIN, QMAX, QMIN should not be changed until the unit is fully decommissioned”. Scott Schichtl second. The motion passed unanimously.

Material: FEB13_Attach3 - 6. SPP Model Development Procedure Manual 2020 v4.0 Feb 2020_Pending_Updated.docx

AGENDA ITEM 7 – BREAK

The group took a 10-minute break.

AGENDA ITEM 8 – 2021 ITP GEN AND LOAD UPDATE

Brooke Keene provided the MDWG group an update on the 2021 ITP generator and load efforts. SPS asked if updates based on member feedback received for the 2020 MPMs will be used in the 2021 load and gen review. Brooke mentioned typically the ABB data is utilized. However, SPP staff will discuss whether to incorporate the feedback.

AGENDA ITEM 9 – NERC TPL-001-5 STANDARD UPDATE

Jonathan Hayes gave an update on TPL-001-5. Jonathan mentioned there will be changes to spare equipment strategy, outages included in the models, etc. Jonathan mentioned TPLTF is been putting together a document for the rationale of selecting outages for inclusion in TPL assessments and will bring it to the MDWG for review. Jonathan encouraged entities to participate in TPLTF and provide feedback on the rationale. Chris Colson clarified that the inclusion of known outages removed from requirement 1 to requirement 2 of TPL-001-5 and the outages are no longer directly tied to duration.

Jeremy Harris asked since TPL has traditionally been run on peak cases, do the changes in TPL-005-1 open up the TPL assessment for other seasonal cases. Chris Colson responded that TPL-001-5 will probably become effective 6/1/2025 and by transferring the outages under R2, the base models should be built using the requirements in the model build manual and then entities will have the flexibility to select outages in their TPL assessments for inclusion in the study.
MDWG MINUTES
February 13, 2020

AGENDA ITEM 10 – 2019 SERIES MOD-033-1 VALIDATION SCOPE INTRODUCTION

Agenda item tabled for a future MDWG meeting.

AGENDA ITEM 11 – WORKSHOP AGENDA ITEMS REVIEW

Nate Morris reminded the group to take part in the Doodle Poll that staff sent out for the workshop meeting dates. Sunny Raheem outlined the current list of workshop topics that staff has created. Sunny mentioned that staff would welcome any additional questions for topics from members. Holli Krizek asked if the workshop has the same focus as last year’s workshop. Sunny mentioned that based on the workshop survey, this year’s workshop would focus more on hands-on demonstrations of MOD, EDST, and how to submit data.

AGENDA ITEM 12 – SUMMARY OF ACTION ITEMS

1. Moses to include language about aux load in the ITP models in the posting email.

AGENDA ITEM 13 – DISCUSSION OF FUTURE MEETINGS

Nate Morris outlined the future MDWG, MDWG workshop, MDWG focus groups, and MDWG manual task force meetings

AGENDA ITEM 14 – ADJOURN (APPROVAL ITEM)

Nate Morris asked the group if they had any other topics for discussion before the group adjourned. The group did not voice any additional topics.

Motion: Jason Shook motioned to adjourn the meeting. Andy Berg seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at 12:05 pm (CST).

Respectfully Submitted,

Sunny Raheem

Secretary
AGENDA

1. Administrative Items .................................................................Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous January 22, 2020 Meeting Minutes (Approval Item)
2. Review of Past Action Items ..........................................................Sunny Raheem (5 mins)
3. SPP Dynamic Load Task Force Update ..............................................Scott Jordan (10 mins)
4. MDWG Generation Dispatch FG Update ......................................Steve Hohman/Lottie Richardson (20 mins)
5. 2020 series MDWG Model Updates
   a. Powerflow .................................................................Moses Rotich/All (30 mins)
   b. Short Circuit .................................................................Michael Odom (10 mins)
   c. Dynamics ..................................................................Shahrokh Akhlaghi (10 mins)
6. MDWG Manual Language Approval (Approval Item*) ..............Michael Odom/All (20 mins)
7. Break .........................................................................................................................(10 mins)
8. 2021 ITP Gen and Load Update .....................................................Brooke Keene (15 mins)
9. NERC TPL-001-5 Standard Update ......................................................Jonathan Hayes (5 mins)
10. 2019 series MOD-033-1 Validation Scope Introduction ...............Becca McCann (15 mins)
11. Workshop Agenda Items Review .........................................................Sunny Raheem (15 mins)
12. Summary of Action Items ...........................................................Nate Morris/Sunny Raheem (5 mins)
13. Discussion of Future Meetings .........................................................Nate Morris (10 mins)
a. **MDWG**: March 12, 2020 Conference Call (9:00AM – 12:00PM CST)
b. **Manual Task Force**: February 27, 2020 (10:00AM-12:00PM CST)
c. **Focus Groups Meetings**:
   i. Power Flow: February 17, 2020 (9:30AM – 11:30AM CST)
   ii. Short Circuit: May 12, 2020 (9:00AM – 11:00AM CDT)
   iii. Dynamics: April 22, 2020 (10:00AM – 12:00PM CDT)
   iv. Generation Dispatch: February 26, 2020 (2:00PM – 4:00PM CST)

14. Adjourn (**Approval Item**) .................................................................................................................................. All

**Note**: The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG.
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. Staff to communicate to upper SPP management about collective feedback from the Age and Condition Discussion. Additionally note the summary of the discussion within the TWG report.
2. Staff to follow up on how short circuit tie line data with AECI is applied.
3. Staff should review the accuracy of the EDST tie line data before the 2/7 member deadline.
4. Staff to update the manual task force meeting time and calendar.
5. Staff to send out enhancement list for ranking enhancement list.
Motions:

1. Jason Shook motioned to adopt the agenda. Scott Schichtl seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

2. Jason Shook moves to approve the December 5, 2019 meeting minutes as presented in the background meeting materials. Scott Schichtl seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

3. Jason Shook moves to approve the December 13, 2019 meeting minutes. Jeremy Harris seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

4. Jerad Ethridge motioned to adjourn the meeting. Holli Krizek seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.
AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

SPP MDWG Chair, Nate Morris, called the meeting to order at 8:30 am with Quorum. SPP Staff Secretary, Sunny Raheem, read the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES
The following members attended or represented by proxy:

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<tr>
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<th>Proxy</th>
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<tr>
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<td>Empire District Electric Company, MDWG Chair</td>
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<td>Jerad Ethridge</td>
<td>YES</td>
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<td>Oklahoma Gas &amp; Electric, MDWG Vice-Chair</td>
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<td>Charles Aleman</td>
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<td>Andrew Berg</td>
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<td>Missouri River Energy Services</td>
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<td>Preston Blinsky</td>
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<td>City Utilities of Springfield</td>
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<td>Joe Fultz</td>
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<td>Jeremy Harris</td>
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<td>KCP&amp;L and Westar, Evergy Companies</td>
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<td>Jason Hofer</td>
<td>YES</td>
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<td>Nebraska Public Power District</td>
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<td>Steve Hohman</td>
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<td>Omaha Public Power District</td>
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<td>Holli Krizek</td>
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<td>Jordan Lamb</td>
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<td>Reené Miranda</td>
<td>NO</td>
<td>Frank Fabela</td>
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<td>Alex Mucha</td>
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<td>Liam Stringham</td>
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<td>Sunny Raheem</td>
<td>YES</td>
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<td>Southwest Power Pool, Inc., MDWG Secretary</td>
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Additional Guests:

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<td>Dona Parks</td>
<td>Grand River Dam Authority</td>
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<td>Bryan Haslinger, Michael Wegner</td>
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<td>Ben Hammer, Brianna Haug, Chris Colson, Jeffrey Anderson, Josie Daggett</td>
<td>Western Area Power Administration</td>
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AGENDA ITEM 1E – AGENDA REVIEW

Nate Morris asked the group if they had chance to review the agenda and if the group has any modifications to the agenda. The group did not voice any modifications.

Motion: Jason Shook motioned to adopt the agenda. Scott Schichtl seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

Nate Morris asked the group if they had any comments about the posting of the background materials. Jason Shook commented that a late posting made the afternoon before the meeting, which made it difficult for members to review the materials. The group discussed the impact of the late posting and noted that the material posted were not approval items. Sunny Raheem mentioned he would like to apologize on the behalf of staff for the late posting. Sunny mention the late posting is partial due to the timing of the industry meeting before the MDWG meeting, which resulted in the staff member submitting the materials late to account for the recent industry meeting discussions and outcome.

Material: JAN22_Attach1 - 1e. MDWG Meeting Agenda 20200122.docx

AGENDA ITEM 1F – PREVIOUS MEETING MINUTES

Nate Morris asked the group if they had any modification to the December 5, 2019 meeting minutes. Sunny Raheem mentioned he incorporated the redlines proposed by SPS into the posted meeting minutes. Sunny mentioned that staff agrees with the SPS proposed redlines. There was no additional discussion or feedback to the minutes from the group.

Motion: Jason Shook moves to approve the December 5, 2019 meeting minutes as presented in the background meeting materials. Scott Schichtl seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

Material: JAN22_Attach2 - 1fi. MDWG Minutes December 5, 2019.pdf

Nate Morris asked the group if they had any modification to the December 13, 2019 meeting minutes. The group did not voice any changes.

Motion: Jason Shook moves to approve the December 13, 2019 meeting minutes. Jeremy Harris seconded the motion. The group did not voice any changes during the discussion of the motion. The motion passed unanimously.

Material: JAN22_Attach3 - 1fii. MDWG Minutes December 13, 2019.pdf
AGENDA ITEM 2 – MDWG TASK FORCE/FOCUS GROUP UPDATES

AGENDA ITEM 2A – POWERFLOW FOCUS GROUP

Jeremy Harris provided the group a general update for the recent Powerflow Focus Group activities and meeting schedule.

Jeremy Harris provided the group an update on the responses and feedback collected for the age and condition discussion at the powerflow focus group. The group discussed the Transmission Availability Data System (TADS) data and its applicability to the age and condition discussion. Nate Morris mentioned using the previous ITP study constraints to collect age or condition as a way to determine the benefit that it would provide to a regional planning process. Members in the group agreed with Nate’s suggestion. Some members noted that age or condition data already communicated to SPP via Detailed Project Proposals (DPP) submissions. Chris Colson suggested RR391 could be a potential opportunity for this type of data if RR391 is part of the ITP process. Chris mentioned the local zone would have the better understanding for evaluating zone specific aging or condition scenarios. The group discussed how far the model building process has come given now that we are talking about supplemental data gathering efforts.

**Action Item:** Staff to communicate to upper SPP management about collective feedback from the Age and Condition Discussion. Additionally note the summary of the discussion within the TWG report.

Moses Rotich provided a quick update on the status of the Shunt Model testing effort. Moses mentioned staff would do a DocuCheck and ACCC comparison test with the ITP models. The plan would be to bring the results to the power flow focus group. After the focus group has had an opportunity to review the results, then the MDWG manual language will be update and provided to MDWG for consideration of approval.

AGENDA ITEM 2B – SHORT CIRCUIT FOCUS GROUP

Michael Odom provided the group an overview of the proposed quarterly meeting schedule for the focus group going forward. Michael gave an update on the current short circuit model efforts. Joe Fultz asked about the process and data flow for SPP member owned and externally owned tie lines with AECI. Staff mentioned they would coordinate with AECI during the SERC short circuit model build that the correct data is included in future builds. The group discussed a previous discussion about reviewing EDST tie line information. The group requested the EDST data be reviewed before the 2/7 member deadline.
**Action Item:** Staff to follow up on how short circuit tie line data with AECI is applied.

**Action Item:** Staff should review the accuracy of the EDST tie line data before the 2/7 member deadline.

**AGENDA ITEM 2C – DYNAMICS FOCUS GROUP**

Marc Moor gave the group an updated on future quarterly meeting schedules. Marc mentioned the highlights from the meeting going forward. Marc highlighted the collaborative work from the group to troubleshoot the dynamic model, SWCAP.

**AGENDA ITEM 2D – GENERATION DISPATCH FOCUS GROUP**

Steve Hohman commented on the upcoming meeting on January 30, 2020, from 2-4pm. Steve mentioned that if a person has not already registered for the conference please do so at spp.org. Steve summarized the activities from the December meeting including SPP staff had two education sessions regarding ECDI dispatch. Steve mentioned Chris Colson would present on generation dispatch at the upcoming meeting. Steve reminded the group the SPP staff questions about ECDI dispatch are due to SPP by January 17, 2020, in order to prepare for the question and answer session at the upcoming meeting.

**AGENDA ITEM 2E – MANUAL TASK FORCE**

Michael Odom provided a quick update on the meeting schedule for the MDWG manual task force. Some in the group voiced concern on not receiving the latest WebEx invitation.

**Action Item:** Staff to update the manual task force meeting time and calendar.

**AGENDA ITEM 3 – STANDARD IMPEDANCE EFFORT INTRODUCTION**

Sunny Raheem introduced the standard impedance effort. Sunny mentioned the goal is improve transparency and consistency in ITP staff solution data used for regional upgrades. Eddie Watson presented the standard impedance effort by outline the project timeline and milestones, scope, data of interest. The group discussed the benefit and challenges of assign standard impedances for kV levels. The group mentioned that an impedance range would be more beneficial to allow the flexibility to accommodate design for various regions. The group discussed the reasons for removing the typical impedance data table from the MDWG manual in recent years. Some members commented that use PSSE LineProp software to estimate impedance based on structure configuration and conductor type. The group discussed estimating impedance by recently completed project of similar scope and design within a local area. The group discussed and determined that SPP PCWG should be involved in this discussion as PCWG and its standard minimum design task force work.
AGENDA ITEM 4 – BREAK

The group took a 10 minute break.

AGENDA ITEM 5 – 2020 SERIES MDWG MODEL UPDATES

AGENDA ITEM 5A – POWERFLOW UPDATE AND WORKING SESSION

Moses Rotich provided an update on the 2020 series MDWG powerflow models. Moses provided an outline for the posted materials including DocuCheck. Moses summarized the reasoning for reposting an updated 2025L model earlier in the week. Moses mentioned that some Generator Owners are still gathering information requested by staff as part of the model build. Some members of the group voiced concern about the exception template did not apply correctly to the DocuCheck output. Some members of the group voiced concern over the ratings in the light load cases in pass 2. Moses led the group in reviewing tabs in DocuCheck that require data submitter updates. The group reviewed the DocuCheck Graphs. Lottie Richardson ran an updated DocuCheck with the exception template applied and notified the group of the new DocuCheck. Moses present the some of the most important “red” tabs including swing machines offline, pgen out of range, and facilitates that are overloaded in the base cases.

AGENDA ITEM 5B – SHORT CIRCUIT

Michael Odom summarized the 2020 series MDWG short circuit model builds. Michael mentioned the models posted on January 17, 2020. Michael mentioned he has received many MISO data back and is working with the contractor to map it. Michael reminded the group the data updates from data submitters are due back by February 7, 2020.

AGENDA ITEM 5C – DYNAMICS

Sunny Raheem provided a quick update and review of the 2020 series MDWG dynamic model build schedule. Sunny mentioned that staff posted the initial data last week and members will have until February 21, 2020 to provide updates. Sunny mentioned that this model build would not able to accept user-written models and unacceptable models per the NERC acceptable model list.
AGENDA ITEM 6 – LUNCH

AGENDA ITEM 7 – EDST ENHANCEMENT LIST REVIEW

Lottie Richardson presented the EDST enhancement list to the group. The next EDST enhancement release scheduled for implementation in mid-July 2020. SPP Engineering Modeling selected the Top three enhancement features application lock down, EDST member communication revisions, and compliance trail based on multiple similar comments provided by members, which included 1) Application Lock Down, 2) EDST Member Communication Revisions, and 3) Compliance Trail. Staff asked if the group had any suggestions on the next data set to include in the EDST database. The group discussed the need for modeling contacts, GMD data, and dynamics data. Some in the group requested member review of all the submitted enhancements.

Action Item: Staff to send out enhancement list for ranking enhancement list.

AGENDA ITEM 8 – BREAK

The group took a 10 minute break.
AGENDA ITEM 9 – NERC STANDARDS UPDATE

Shannon Mickens provided an NERC Standards update including highlights from the NERC Planning Committee (PC) December meeting. The NERC PC meeting discussed the MOD-032 Standard Authorization Request (SAR), Synchronized Measurements Subcommittee (SMS) Whitepaper, and Inverter-Based Resource Performance Task Force (IRPTF) Whitepaper. Shannon mentioned the NERC System Planning Impact for Distributed Energy Resources Working Group sent a DER survey out all entities that participant in SPIDERWG. Sunny Raheem mentioned NERC requested Planning Coordinators to share the survey with their data submitters and members that are not on the SPIDERWG email lists. Sunny mentioned he communicated the survey via email the week before the meeting.

AGENDA ITEM 10 – SPIDERWG DER DATA COLLECTION RELIABILITY GUIDELINE REVIEW

Sunny Raheem presented the current draft of the SPIDERWG DER Data Collection Reliability Guideline that is currently being developed. Sunny mentioned that he did get approval from NERC staff to share this draft copy with the group in efforts of collecting comments to help build out the reliability guideline. The group reviewed the MOD-032-1 data collection process language, MOD-032-1 Data collection and DER, and DER Modeling Needs for TPs and PCs. Some in the group commented that inverter based DER could have different d-curves and require additional active and reactive power requirements at maximum operating states.

AGENDA ITEM 11 – ORGANIZATIONAL EFFECTIVENESS SURVEY RESULTS AND ACTION PLAN

Nate Morris introduced the group to the organization effectiveness survey results and action plan agenda topic. Sunny Raheem presented the comments that he would like to focus on for improvement in 2020. Sunny recommended that staff provide an education session on GO data collection process. Nate noted this is the first year for non-voting members to participate in the survey. Nate commented that he would like to see the survey completion rate increase going forward. Nate reviewed the lowest scoring areas and provided recommendations for improvement. Nate and Sunny walked the group through all ratings and written comments. Nate and Sunny both communicated their support for the work MDWG completed in 2019 and believe the group provides a lot of benefit. Sunny mentioned the WECC/MRO/NERC site control visit came back with limited planning recommendations for MOD-032-1, which he contributes to the work MDWG completed in 2019. Nate thanked the group for all the feedback and looks forward to what 2020 will provide the group.
AGENDA ITEM 3A – SUMMARY OF ACTION ITEMS

1. Staff to communicate to upper SPP management about collective feedback from the Age and Condition Discussion. Additionally note the summary of the discussion within the TWG report.

2. Staff to follow up on how short circuit tie line data with AECI is applied.

3. Staff should review the accuracy of the EDST tie line data before the 2/7 member deadline.

4. Staff to update the manual task force meeting time and calendar.

5. Staff to send out enhancement list for ranking enhancement list.

AGENDA ITEM 3B – FUTURE MEETINGS

Nate Morris outlined the future MDWG, MDWG workshop, MDWG focus groups, and MDWG manual task force meetings

AGENDA ITEM 3C – ADJOURN

Nate Morris asked the group if they had any other topics for discussion before the group adjourned. The group did not voice any additional topics.

Motion: Jerad Ethridge motioned to adjourn the meeting. Holli Krizek seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at 3:45 pm (CST).

Respectfully Submitted,

Sunny Raheem

Secretary
Attachments

JAN22_Attach1 - 1e. MDWG Meeting Agenda 20200122.docx

JAN22_Attach2 - 1fi. MDWG Minutes December 5, 2019.pdf

JAN22_Attach3 - 1fii. MDWG Minutes December 13, 2019.pdf
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
January 22, 2020
AEP Office - Meeting Space Suite 4103
1201 Elm Street, Dallas TX 75270
• A G E N D A •
8:30 a.m. – 4:00 p.m. (CST)

1. Administrative Items ............................................................................................................. Nate Morris (15 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. December 5, 2019 (Approval Item)
      ii. December 13, 2019 (Approval Item)

2. MDWG Task Force/Focus Group Updates:
   a. Powerflow Focus Group
      i. General Update .................................................... Jeremy Harris/Moses Rotich (15 mins)
      ii. Aging Infrastructure Discussion ......................... Jeremy Harris/Moses Rotich (30 mins)
      iii. Shunt Model Testing Update .............................. Moses Rotich (15 mins)
   b. Short Circuit Focus Group ................................... Reené Miranda/Michael Odom (10 mins)
   c. Dynamics Focus Group ........................................ Marc Moor/Shahrokh Akhlaghi (15 mins)
   d. Model Dispatch Group ........................................... Steve Hohman/Lottie Richardson (15 mins)
   e. Manual Task Force General Update ........................ Michael Odom (5 mins)

3. Standard Impedance Effort Introduction ................................................................. Staff (20 mins)

4. Break ................................................................................................................................. (10 mins)

5. 2020 series MDWG Models Updates
   a. Powerflow Update and Working Session ......................... Moses Rotich/All (90 mins)
   b. Short Circuit .......................................................... Michael Odom (15 mins)
   c. Dynamics .................................................................. Sunny Raheem (15 mins)

6. Lunch ................................................................................................................................. (60 mins)

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
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7. EDST Enhancement List Review .................................................................Lottie Richardson/All (30 mins)
8. Break ..............................................................................................................(10 mins)
9. NERC Standards Update ............................................................................Shannon Mickens (30 mins)
10. SPIDERWG DER Data Collection Reliability Guideline Review .......................All (30 mins)
11. Organizational Effectiveness Survey Results and Action Plan ...............................All (30 mins)
12. Administrative Items ....................................................................................Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings
      i. MDWG
         1. February 13, 2020 Conference Call (9:00AM – 12:00PM CST)
      ii. Manual Task Force:
         1. Biweekly on Thursday (9:00AM-11:00AM CST)
      iii. Focus Groups Meetings:
         1. Power Flow: February 17, 2019 (9:30AM – 11:30AM CST)
         2. Short Circuit: February 11, 2020 (9:00AM – 11:00AM CST)
         3. Dynamics: January 15, 2020 (10:00AM – 12:00PM CST)
         4. Generation Dispatch: January 30, 2020 (2:00PM – 4:00PM CST)
   c. Adjourn

Note: The approval items denoted with “***” shall be jointly developed by PC, TP, and MDWG.
MDWG MINUTES
December 5, 2019

SOUTHWEST POWER POOL
MODEL DEVELOPMENT WORKING GROUP MEETING

December 5th, 2019 9:00 am – 12:00pm (CST)
Conference Call

SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. Action Item: Staff to verify visibility settings for applicable tie line entities in EDST
Motions:

1. Jason Shook motioned to adopt the agenda as modified and presented. The motion passed unanimously.

2. Joe Fultz motioned to approve the October 22-23, 2019 meeting minutes as presented. The motion passed unanimously.

3. Email Vote: Jordan Lamb motioned to approve the proposed 2020 series MDWDG dynamic schedule and model selection (12 reduce models, 2 high wind sensitivities). The motion passed unanimously.

4. Andy Berg motioned to adjourn the meeting. The motion passed unanimously.
MDWG MINUTES
December 5, 2019

SOUTHWEST POWER POOL
MODEL DEVELOPMENT WORKING GROUP MEETING

December 5th, 2019 9:00 am – 12:00pm (CST)
Conference Call

MINUTES

AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

SPP Chair, Nate Morris, called the meeting to order at 9:02 am with Quorum. SPP Staff Secretary, Sunny Raheem, reading the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTendance AND PROXIES

The following members attended or represented by proxy:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Present</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nate Morris</td>
<td>YES</td>
<td></td>
<td></td>
<td>Empire District Electric Company, MDWG Chair</td>
</tr>
<tr>
<td>Jerad Ethridge (9a-11a)</td>
<td>YES</td>
<td>Nate Morris  (11a-12p)</td>
<td>YES</td>
<td>Oklahoma Gas &amp; Electric, MDWG Vice-Chair</td>
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<tr>
<td>Charles Aleman</td>
<td>YES</td>
<td></td>
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<td>Golden Spread Electric Cooperative</td>
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<tr>
<td>Andrew Berg</td>
<td>YES</td>
<td></td>
<td></td>
<td>Missouri River Energy Services</td>
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<tr>
<td>Preston Blinsky</td>
<td>YES</td>
<td></td>
<td></td>
<td>Basin Electric Power Cooperative</td>
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<tr>
<td>John Boshears</td>
<td>YES</td>
<td></td>
<td></td>
<td>City Utilities of Springfield</td>
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<tr>
<td>Joe Fultz</td>
<td>YES</td>
<td></td>
<td></td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Jeremy Harris</td>
<td>YES</td>
<td></td>
<td></td>
<td>KCP&amp;L and Westar, Evergy Companies</td>
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<tr>
<td>Jason Hofer</td>
<td>YES</td>
<td></td>
<td></td>
<td>Nebraska Public Power District</td>
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<tr>
<td>Steve Hohman</td>
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<td></td>
<td></td>
<td>Omaha Public Power District</td>
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<tr>
<td>Holli Krizek</td>
<td>YES</td>
<td></td>
<td></td>
<td>Western Area Power Administration</td>
</tr>
<tr>
<td>Jordan Lamb</td>
<td>YES</td>
<td></td>
<td></td>
<td>East River Electric Power Cooperative</td>
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<tr>
<td>Reené Miranda</td>
<td>NOYES</td>
<td>Aravind Chellappa</td>
<td>YES</td>
<td>Southwestern Public Service</td>
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<tr>
<td>Alex Mucha</td>
<td>YES</td>
<td></td>
<td></td>
<td>Oklahoma Municipal Power Authority</td>
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<tr>
<td>Scott Rainbolt</td>
<td>YES</td>
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<td></td>
<td>American Electric Power</td>
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<td>Scott Schichtl</td>
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<td></td>
<td></td>
<td>Arkansas Electric Cooperative Company</td>
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<tr>
<td>Jason Shook</td>
<td>YES</td>
<td></td>
<td></td>
<td>GDS Associates</td>
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<tr>
<td>Liam Stringham</td>
<td>YES</td>
<td></td>
<td></td>
<td>Sunflower Electric Power Corporation</td>
</tr>
<tr>
<td>Sunny Raheem</td>
<td>YES</td>
<td></td>
<td></td>
<td>Southwest Power Pool, Inc., MDWG Secretary</td>
</tr>
</tbody>
</table>
### Additional Guests:

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<thead>
<tr>
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<th>Company</th>
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<tbody>
<tr>
<td>David Zhong, Phil Westby, Jerry Bradshaw, Jeff Crites</td>
<td>American Electric Power, Basin Electric Power Cooperative, City Utilities of Springfield, The Empire District</td>
</tr>
<tr>
<td>Cristina Ortiz, Lafayette Gatewood, Pallab Datta, Marcus Moor</td>
<td>Evergy Companies</td>
</tr>
<tr>
<td>Dona Parks, Alan Burbach, Edin Terzic, Elaine Sun, Ryan Benton</td>
<td>Grand River Dam Authority, Lincoln Electric System, Midwest Energy</td>
</tr>
<tr>
<td>Bruce Doll, Mark Mallard, Daryl Huslig</td>
<td>Municipal Energy Agency of Nebraska, Northwestern, Oklahoma Gas &amp; Electric</td>
</tr>
<tr>
<td>Audrey White, Hugh Benfer, Jay Caspary, Jeff McDiarmid, Jonathan Hayes, Kimberly Woods, Lottie Richardson, Michael Odom, Moses Rotich, Shahrokh Akhlaghi, Sherri Maxey</td>
<td>Southwest Power Pool, Inc.</td>
</tr>
<tr>
<td>Aravind Chellappa, Brianna Haug, Joe Williams</td>
<td>Southwestern Public Service, Western Area Power Administration, Western Farmers Electric Cooperative</td>
</tr>
</tbody>
</table>
AGENDA ITEM 1E – AGENDA REVIEW

Nate Morris asked the group if they had any modifications to the agenda. Sunny Raheem mentioned he had redlines for updating the future meeting schedules and to the age and condition of transmission discussion item in case the presenter was not able to attend. The group did not voice any addition modifications.

**Motion: Jason Shook motioned to adopt the agenda as modified and presented. Jerad Ethridge seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.**

Material: DEC5_MM_Attach1 - 1e. MDWG Meeting Agenda 20191205_redlined.docx

AGENDA ITEM 1F – PREVIOUS MEETING MINUTES

Nate Morris asked the group if they had any modification to the October 22-23, 2019 meeting minutes. Sunny Raheem mentioned that SPP has a new template for meeting minutes that he incorporated in this set of meeting minutes. The group discussed the template layout for the meeting minutes. There was no additional discussion or feedback to the minutes from the group.

**Motion: Joe Fultz motioned to approve the October 22-23, 2019 meeting minutes as presented. Andy Berg seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.**

Material: DEC5_MM_Attach2 - 1f. MDWG Minutes October 22, 2019.pdf

AGENDA ITEM 1G – ACTION ITEM REVIEW

Sunny presented an overview of the action items and briefly discussed recently completed items. Sunny reviewed staffs’ comments as denoted in red font since the last meeting for in-progress action items. There was no additional discussion or feedback to the action items from the group.
AGENDA ITEM 2 – ITP QUARTERLY REPORT CARD

Sherri presented the ITP Quarterly Report Card to the MDWG group. Sherri outlined the 2020 ITP milestones in mitigation as listed on slide 5 of the ITP Quarterly Report Card. Sherri provided the 2020 ITP mitigation milestone plan to go to green. Sherri provided a summary of 2021 ITP milestones and their status. Sherri noted the milestones listed in slide 7 are all on track. The group reviewed the presentation and requested it be made available. Staff mentioned it would be posted with the meeting minutes materials.

Material: DEC5_MM_Attach3 - ITP Quarterly Report Card_Dec2019.pptx

AGENDA ITEM 3 – 2019 SERIES MDWG MODELS UPDATE

AGENDA ITEM 3A – DYNAMIC MODELS FOR SPP 2020 TPL

Sunny Raheem provided the group an update on the status for the 2019 series MDWG dynamic model updates for SPP’s 2020 TPL assessment. Sunny reminded the group the proposed models are posted for review until the approval call scheduled for December 13, 2019.
AGENDA ITEM 4 – 2020 SERIES MDWG MODEL UPDATES

AGENDA ITEM 4A – POWERFLOW

Moses Rotich provided an update on the status of the 2020 series MDWG powerflow models. Moses displayed the posting email sent on November 15, 2019 as the Pass 1 – Trial 2 powerflow model posting for review notification. Moses outlined the GlobalScape folder structure for uploading data, understanding of data requested in the current model build pass, significant changes to the models including a new modeling area, overview of MOD enhancements, and reminders for MOD-033-1 unacceptable differences, new version of PowerflowChecker, and SPP Modeling Assignments. The group discussed the items presented. Moses mentioned the deadline of December 13, 2019 for generator additions & retirements, loads and interchange. AEP noted concerns about SPP tie lines and issues experienced in EDST. AEP mentioned they are missing tie lines and have information being overwritten during the MDWG and MMWG merge. Moses provided clarification on the tie line concern due to the functionality of EDST’s visibility to applicable entities. The group discussed the need to review EDST tie lines. Staff suggested noting an action item to review tie lines, which the group agreed to the action item.

After the tie line discussion, Moses presented the MOPC action item for Bakken load addition recommendation for incorporate Bakken area load and generation supply issues in the 2021 ITP (2020 MDWG series). Moses opened the floor up for questions for staff and Basin representatives after his description of the Bakken load additions. The group did not voice concerns.

Action Item: Staff to verify visibility settings for applicable tie line entities in EDST

AGENDA ITEM 4B – SHORT CIRCUIT

Michael Odom provided an update for the short circuit model build including the recent posting and current pass data requirements. Michael mentioned the MISO data from MISO TOPs has started coming through and staff is working on reviewing it for incorporation into the next pass. Michael mentioned either staff or the consultant would have to map the MISO data since it is in varying formats. The group asked who the consultant is for the short circuit build. Staff mentioned it is Siemens PTI for this project.
AGENDA ITEM 4C – DYNAMICS

Sunny Raheem provided an update on the approval process for the 2020 series MDWG dynamic model build. Sunny mentioned that staff incorporated the proposed changes to the schedule from the October MDWG meeting the updated schedule was sent out for MDWG membership approval via email voting protocols. Sunny mentioned the updated schedule was approved and will post in the next day.

Email Motion Results: Jordan Lamb motioned to approve the proposed 2020 series MDWDG dynamic schedule and model selection (12 reduce models, 2 high wind sensitivities). Andy Berg seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

AGENDA ITEM 5 – BREAK

The group took a 10-minute break.

AGENDA ITEM 6 – AGE AND CONDITION OF TRANSMISSION

Jay Caspary provided an objective for age and condition of transmission infrastructure presentation. Jay mentioned this presentation has already been provided to TWG. The presentation covered 345kV growth from 1949 – 2010 and review of the current day 345kV system. The presentation covered results from an independent research project and survey. The group reviewed the conclusion and next steps slide. Sunny Raheem covered a potential roadmap for implementing for the 2022 ITP if the group was interested. The roadmap included discussion of a data collection template for discussion at the upcoming MDWG powerflow focus group, EDST software requirements, TWG and ESWG discussions needed for potential opportunities to include the data in ITP decision making.

After the roadmap discussions, Nate Morris conducted a straw poll response from the group on next steps. Most of the group mentioned they believe the discussion is warranted, but were unsure if age data is the best measurement for replacement. The group discussed other possibilities including developing a methodology. Some members of the group voiced concern on the use of the data. Jay mentioned the use of the data would have to go through stakeholder working group approval, but it would assist SPP in enhanced decision making for upgrades. The group in general agreed to have the MDWG powerflow focus group discuss the data collection template at their next meeting.

Reené Miranda expressed concerns on why data is being collected and if NTCs would be issued for the upgrading aging, primarily since SPP has not developed, nor presented a process/plan detailing how the data will be used. Reené noted that a process to address Age and Condition of Transmission should first be developed and presented for approval prior to the collection of any data.
AGENDA ITEM 7 – MDWG TASK FORCE/FOCUS GROUP UPDATES

AGENDA ITEM 7A – POWERFLOW FOCUS GROUP

Jeremy Harris recapped recent discussion from the powerflow focus group, which included the group discussion the PSSE v34 twelve ratings, node-breaker modeling approach, and reviewing the powerflow model posting email in more detail. Jeremy went over the future meeting schedule.

AGENDA ITEM 7B – SHORT CIRCUIT FOCUS GROUP

Reené Miranda provided an update on the short circuit focus group moving to a quarterly meeting schedule. Reené mentioned the short circuit group would not meet the rest of the year to allow staff and members of the group time to complete other compliance assessment requirements, which are due by the end of the year. Michael Odom commented that the MISO short circuit data is coming in and staff is working with the consultant to incorporate it in the current model build. Reené mentioned that group is working on scheduling future meetings.

AGENDA ITEM 7C – DYNAMICS FOCUS GROUP

Marc Moor summarized recent activities occurring at the dynamic focus group including MINs language discussion and education, industry debriefs, composite load modeling efforts, NERC PPVTF MOD-025 SAR efforts for removing or changes to the MOD-032-1 standard for generators, and NERC SPIDERWG’s MOD-032-1 SAR edits. Sunny Raheem thanked Marc for his efforts in keeping up with the industry working group items and providing the dynamic focus group great summaries.

AGENDA ITEM 7D – MODEL DISPATCH FOCUS GROUP

Steve Hohman provided an outline of the discussion from the first Model Dispatch Focus Group. Steve and staff mentioned there was good conversation and discussion during the first meeting. The group reviewed ECDI information for the SPP ITP base reliability models. The group is currently thinking about an ECDI approach for the MDWG models. The group will start back in January after staff receives all the schedule input from the focus group members.

AGENDA ITEM 7E – MANUAL TASK FORCE

Michael mentioned the group is taking a break and will pick up back in January.
AGENDA ITEM 8 – ADMINISTRATIVE ITEMS

AGENDA ITEM 8A – SUMMARY OF ACTION ITEMS

The group reviewed the action items.

AGENDA ITEM 8B – FUTURE MEETINGS

Nate Morris outlined the future MDWG, MDWG focus groups, and MDWG manual task force meetings. Nate mentioned he will miss the next call so he assigned Chair responsibilities and voting proxy to Jerad Ethridge for the December 13th, 2019 MDWG conference call. Sunny Raheem mentioned he has a conflicting meeting and will assign his secretary proxy to Moses Rotich for the December 13th, 2019 conference call.

AGENDA ITEM 8C – ADJOURN

Nate asked the group if they had any other topics for discussion before the group adjourned. The group did not voice any additional topics.

Motion: Andy Berg motioned to adjourn the meeting. Jordan Lamb seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at 12:07 pm (CST).

Respectfully Submitted,

Sunny Raheem

Secretary
Attachments

DEC5_MM_Attach1 - 1e. MDWG Meeting Agenda 20191205_redlined.docx

DEC5_MM_Attach2 - 1f. MDWG Minutes October 22, 2019.pdf

DEC5_MM_Attach3 - ITP Quarterly Report Card_Dec2019.pptx
Southwest Power Pool, Inc.

MODEL DEVELOPMENT WORKING GROUP

December 5th, 2019

Conference Call
• A G E N D A •

9:00 a.m. – 12:00 p.m. (CST)

1. Administrative Items ................................................................................................................. Nate Morris (15 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. October 22-23, 2019 (Approval Item)
   g. Action Items Review
2. ITP Quarterly Report card ........................................................................................................... Sherri Maxey (15 mins)
3. 2019 series MDWG Models Update
   a. Dynamic Models for SPP 2020 TPL .................................................. Sunny Raheem (5 mins)
4. 2020 series MDWG Models Updates
   a. Powerflow .......................................................................................... Michael Odom (10 mins)
   b. Short Circuit ..................................................................................... Shahrokh Akhlaghi (10 mins)
   c. Dynamics .......................................................................................... Michael Odom (5 mins)
5. Break ................................................................................................................................. (10 mins)
6. Age and Condition of Transmission ......................................................................................... Jay Caspary/Sunny Raheem (45 mins)
7. MDWG Task Force/Focus Group Updates:
   a. Powerflow Focus Group ................................................................. Jeremy Harris/Moses Rotich (10 mins)
   b. Short Circuit Focus Group ............................................................ Reené Miranda/Michael Odom (10 mins)
   c. Dynamics Focus Group ................................................................. Marc Moor/Sunny Raheem (10 mins)
   d. Model Dispatch Group ................................................................. Steve Hohman/Lottie Richardson (10 mins)
   e. Manual Task Force .............................................................................. Michael Odom (5 mins)

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8. Administrative Items ...........................................................................................................Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings
      i. MDWG
         1. Next Conference Call:
            a. Approval Call for 2019 Series MDWG Dynamic Model Set for 2020 TPL December 19th, 2019 (9:00AM – 11:00AM CST)
         2. Next Face-to-Face: TBD January 22nd, 2020 Dallas TX (8:30AM – 4:00pm CST)
      ii. Manual Task Force:
         1. Biweekly on Thursday 9:00am-11:00am (CST)
      iii. Focus Groups Meetings:
         1. Power Flow: December 16th, 2019 (9:30AM – 11:30AM CST)
         2. Short Circuit: TBD – Pending Group Discussion
            3. Dynamics: TBD – Pending Meeting Survey Responses
               3.4. Model Dispatch: TBD – Pending Meeting Survey
   c. Adjourn

Note: The approval items denoted with “**” shall be jointly developed by PC, TP, and MDWG.
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. Staff to post the MDWG manual comparison to GlobalScape.

2. Nate to reach out to task force members for leadership opportunity.

3. Staff to research if ODMS can be purchased for use in Node-Breaker modeling.

4. Justification for the branch zero sequence impedance ratio criteria and review by the short circuit focus group.

5. Staff to send out revised 2020 series MDWG dynamic model build schedule adjusted for an earlier MDWG finalization date within two weeks.

6. Staff to communicate the GlobalScape path to MDWG.
Motions:

1. Jason Shook motioned to adopt the agenda. The motion passed unanimously.

2. Jerad Ethridge motioned to approve the September 12, 2019 meeting minutes as presented. The motion passed unanimously.

3. Jason Shook motioned to approve the September 18, 2019 meeting minutes as presented. The motion passed unanimously.

4. Jordan Lamb motioned to approve the proposed 2020 series MDWDG dynamic schedule and model selection (12 reduce models, 2 high wind sensitivities). Facilitated through SPP email voting protocol. The motion passed unanimously.

5. Jason Shook moved to motion approving PSSE version 34.6.1 for the 2020 series dynamic model build. The motion passed with one abstention.

6. Reené Miranda motioned to adjourn the meeting. The motion passed unanimously.
MDWG MINUTES
October 22, 2019

SOUTHWEST POWER POOL
MODEL DEVELOPMENT WORKING GROUP FACE-TO-FACE MEETING

October 22nd, 2019 8:30 am – 5:00pm (MDT)
Xcel Offices, 2nd Floor, Conference Room A, 1800 Larimer St – Denver Colorado 80202

MINUTES

AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

SPP Chair, Nate Morris, called the meeting to order at 8:32 am with Quorum. SPP Staff Secretary, Sunny Raheem, reading the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES

The following members attended or represented by proxy:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Present</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nate Morris</td>
<td>YES</td>
<td></td>
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<td>Empire District Electric Company, MDWG Chair</td>
</tr>
<tr>
<td>Jerad Ethridge</td>
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<td>Oklahoma Gas &amp; Electric, MDWG Vice-Chair</td>
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<td>Charles Aleman</td>
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<td>Golden Spread Electric Cooperative</td>
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<td>Missouri River Energy Services</td>
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<td>Preston Blinsky</td>
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<td>Basin Electric Power Cooperative</td>
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<td>John Boshears</td>
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<td>City Utilities of Springfield</td>
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<tr>
<td>Joe Fultz</td>
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<td>Grand River Dam Authority</td>
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<tr>
<td>Jeremy Harris</td>
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<td>KCP&amp;L and Westar, Evergy Companies</td>
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<tr>
<td>Jason Hofer</td>
<td>YES</td>
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<td>Nebraska Public Power District</td>
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<tr>
<td>Steve Hohman</td>
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<td>Omaha Public Power District</td>
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<tr>
<td>Holli Krizek</td>
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<tr>
<td>Jordan Lamb</td>
<td>YES</td>
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<tr>
<td>Reené Miranda</td>
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<tr>
<td>Alex Mucha</td>
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<tr>
<td>Scott Schichtl</td>
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<tr>
<td>Jason Shook</td>
<td>YES</td>
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<td>GDS Associates</td>
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<tr>
<td>Liam Stringham</td>
<td>YES</td>
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<td>Sunflower Electric Power Corporation</td>
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<tr>
<td>Sunny Raheem</td>
<td>YES</td>
<td></td>
<td></td>
<td>Southwest Power Pool, Inc., MDWG Secretary</td>
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</tbody>
</table>
**MDWG MINUTES**  
*October 22, 2019*

**Additional Guests:**

<table>
<thead>
<tr>
<th>Guests</th>
<th>Company</th>
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<tbody>
<tr>
<td>Brad Myers, David Zhong, Martin Green</td>
<td>American Electric Power</td>
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<tr>
<td>Josh Hesselbein</td>
<td>Arkansas Electric Cooperative</td>
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<td>Jeremy Severson, Phil Westby</td>
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<td>Jerry Bradshaw</td>
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<td>Tyler Baxter</td>
<td>Corn Belt Power Cooperative</td>
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<tr>
<td>Jeff Crites</td>
<td>The Empire District</td>
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<tr>
<td>Cristina Ortiz, Lafayette Gatewood, Pallab Datta, Marcus Moor, Ryan Baysinger</td>
<td>Evergy Companies</td>
</tr>
<tr>
<td>Diego Toledo, Dona Parks</td>
<td>Grand River Dam Authority</td>
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<tr>
<td>Michael Wenger</td>
<td>ITC Great Plains</td>
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<tr>
<td>Edin Terzic</td>
<td>Lincoln Electric System</td>
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<tr>
<td>Ryan Benton</td>
<td>Midwest Energy</td>
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<tr>
<td>Armin Sehic</td>
<td>Municipal Energy Agency of Nebraska</td>
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<td>Mark Mallard</td>
<td>Northwestern</td>
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<td>Scott Mijin</td>
<td>Southwestern Power Administration</td>
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<td>Aravind Chellappa, Frank Favela</td>
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<td>Eli Nyambegera, Tanner New</td>
<td>Sunflower Electric Cooperative</td>
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<td>Brianna Haug, Chris Colson, Garrick Nelson</td>
<td>Western Area Power Administration</td>
</tr>
<tr>
<td>Joe Williams</td>
<td>Western Farmers Electric Cooperative</td>
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AGENDA ITEM 1E – AGENDA REVIEW

Nate Morris asked the group if they had any modifications to the agenda. The group did not voice any modifications.

**Motion:** Jason Shook motioned to adopt the agenda. Holli Krizek seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

**Material:** OCT22_MM_Attach1 - 1e. MDWG Meeting Agenda 20191022-23.docx

Agenda Item 1F – Previous Meeting Minutes

Nate Morris asked the group if they had any modification to the September 12, 2019 meeting minutes. There was no additional discussion or feedback to the minutes from the group.

**Motion:** Jerad Ethridge motioned to approve the September 12, 2019 meeting minutes as presented. Scott Schichtl seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

**Material:** OCT22_MM_Attach2 - 1fi. MDWG Minutes September 12, 2019.pdf

Nate Morris asked the group if they had any modification to the September 18, 2019 meeting minutes. There was no additional discussion or feedback to the minutes from the group.

**Motion:** Jason Shook motioned to approve the September 18, 2019 meeting minutes as presented. Jeremy Harris seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

**Material:** OCT22_MM_Attach3 - 1fii. MDWG Minutes September 18, 2019.pdf

AGENDA ITEM 1G – ACTION ITEM REVIEW

Sunny presented an overview of the action items and briefly discussed recently completed items. Sunny reviewed staffs’ comments since the last meeting for in-progress action items. The group discussed the need to post the MDWG manual change comparison to GlobalScape. There was no additional discussion or feedback to the action items from the group.

**Action Item:** Staff to post the MDWG manual comparison to GlobalScape.
AGENDA ITEM 2 – MODEL BUILD AND ITP STUDY TIMELINES

Staff presented the compressive overview of MDWG and ITP model builds and SPP ITP study timelines. The group mentioned they would like to see this presentation from time to time. The group requested additional information about the ITP Section 10.3 timeframe. Eddie Watson provided an overview of the Section 10.3 process. The group discussed if recently executed GIA/DPAs should be added during the Section 10.3 timeframe. The group discussed the importance of communicate accurate model series information when data is requested from and to members. The group requested that MDWG and ITP models have their approvals on the same date in the February/March timeframe. The group asked about the level of review for the Generator Interconnection Models. Sunny Raheem explained the Generator Interconnection base models are built for every cluster and are available upon request. Transmission Owners assisting with the study can request the models for their review.

AGENDA ITEM 3 – MDWG POWERFLOW FOCUS GROUP

AGENDA ITEM 3A – STAFF DISPATCH PROPOSALS FOR MDWG MODELS

Lottie Richardson presented the staff dispatch proposals developed so far for MDWG models. Lottie mentioned the proposals were presented at the recent MDWG powerflow focus group and include any suggestions from that meeting. The group review the proposals and provided several comments. Members of the group mentioned they would like to see non-firm service that is actually operating in current day to be included in the dispatch. Some members of the group mentioned it would be beneficial to have a central balance authority approach rather using the modeling areas to balance. After a lengthy conversation with various suggestions, the group decided to form a focus group to review the dispatch in preparation for the 2021 series MDWG build. The group collected names of interested parties that would like to participants on the dispatch focus group.

Action Item: Nate to reach out to task force members for leadership opportunity.
AGENDA ITEM 3B – NODE-BREAKER MODELING APPROACH

Jeremy Harris presented Evergy’s Tecumseh Hill substation node-breaker representation as an example of the node-breaker modeling. Jeremy provided the group with a python script and slider diagram for the group reference. The group talked about the 2021 series MDWG node-breaker modeling approach for 230kV and higher kV. The group questioned if PSS® ODMS could help with the node-breaker mapping effort. Western Area Power Administration representative mentioned they utilized PSS® ODMS, which assisted SPP with their Western Interconnection MOD-033-1 powerflow mapping. The group discussed the SPP internship project’s assistance with the mapping effort in lieu of additional software. During the meeting, no members voiced concern over the SPP internship project in efforts of building out the lower kV level. The group discussed the benefits of including switches and disconnects in the node-breaker modeling. The group determined switches/disconnects might help with constraint mitigation.

**Action Item:** Staff to research if ODMS can be purchased for use in Node-Breaker modeling.

AGENDA ITEM 4 – MDWG SHORT CIRCUIT FOCUS GROUP

AGENDA ITEM 4A – GENERAL UPDATE

Reené Miranda recapped recent meeting topics and mentioned the short circuit focus group is moving to a quarterly meeting schedule going forward since the group has worked through most of their active discussions. Michael Odom provided an update on the MISO Transmission Owner short circuit data collection effort.

AGENDA ITEM 4B – NEW DOCUCHECK

Hugh Benfer walked the group through the new short circuit DocuChecks including zero sequence for branches, 2-winding transformers, and 3-winding transformers. The group requested justification for the branch zero sequence impedance ratio criteria and review by the short circuit focus group. Hugh presented the Zero sequence branch ratings, generator data and load data checks. The group thanked Hugh for automating the new checks.

**Action Item:** Justification for the branch zero sequence impedance ratio criteria and review by the short circuit focus group.
AGENDA ITEM 5 – BREAK

The group took a 15-minute break.

AGENDA ITEM 6 – MDWG DYNAMICS FOCUS GROUP

AGENDA ITEM 6A – GENERAL UPDATE

Marc Moor presented the group an overview of recent and upcoming activities for the MDWG dynamic focus group. Marc presented an overview of EMPT modeling discussions and mentioned that AEP provided a very informative presentation about EMPT models. Marc mentioned the industry is starting to pass around common issues with the dynamic GENTPJ models. Marc outlined the upcoming meetings and meeting plan for 2020.

AGENDA ITEM 6B – 2020 MDWG DYNAMIC MODEL BUILD

Sunny Raheem presented the staff proposed 2020 series dynamic model build schedule. Sunny mentioned the schedule is mostly the same as the previous year besides the additional testing included in the dynamic models because of member request and building the high wind models earlier in the schedule to allow additional review time. The group review the schedule during the meeting. NPPD mentioned the MDWG finalization is about three weeks further out from the 2019 series and they would like to see it align with the 2019 series finalization date. The group agreed they would like to see the finalization date earlier in the year to provide sufficient time for members to perform TPL assessments on the models. Staff mentioned they could revise the schedule to accommodate the request and outline the model selection requests. The group agreed to review the revised schedule and facilitate the approval via SPP email vote protocol.

Action Item: Staff to send out revised 2020 series MDWG dynamic model build schedule adjusted for an earlier MDWG finalization date within two weeks.

Email Voting Results:

Motion: Jordan Lamb motioned to approve the proposed 2020 series MDWDG dynamic schedule and model selection (12 reduce models, 2 high wind sensitivities). Andy Berg seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.
The group discussed the PSSE version v34.6.1 recommendation to align with the same PSSE version as the 2020 series powerflow and short circuit model builds. One member of the group voiced that their company might have expired issues with v34.6.1. Staff mentioned that they have no encountered any major issues through the limited testing performed so far.

**Motion:** Jason Shook moved to motion approving PSSE version 34.6.1 for the 2020 series dynamic model build. Scott Schichtl seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed with one abstention.

The abstention reasoning John Boshears is that CUS was unable to confirm the status of the PSS/E revision and the possible implications. CUS abstains and will confirm internally with possible concerns if any remain, otherwise CUS will support moving forward with the revision presented.

The group reviewed the MDWG dynamic revised acceptable model guidelines. The group discussed if the guidelines should include typical parameters or not. The group discussed if the guideline changes require MDWG approval. The group did not make a recommendation to the approval decision during the meeting but agreed to revisit the topic at a future meeting with the unacceptable models updated from the 2019 series.

**AGENDA ITEM 7 – LUNCH**

The group took a lunch break.

**AGENDA ITEM 8 – 2019 SERIES MDWG MODELS UPDATE**

**AGENDA ITEM 8A – DYNAMIC MODELS FOR SPP 2020 TPL**

Sunny Raheem provided an update on the status for the SPP 2020 TPL dynamic models. Sunny mentioned that staff is anticipating an on schedule posting for the proposed models on 11/21/2019. The group asked if the high wind models would be included in that posting. Sunny mentioned they would be included.
AGENDA ITEM 9 – 2020 SERIES MODELS UPDATE

Lottie Richardson provided a status update for the 2020 series MDWG powerflow models. Lottie updated the group on the current Model On Demand (MOD) updates, report card, and load/generation additions/retirements. Lottie mentioned to the group the inclusion of the MMWG merge as part of Pass 1 Trial 2. The group communicated some concerns with EDST. GRDA mentioned he has a changeset that is having issues with approval. Lottie mentioned the bus should be added to the bus details table first and then a changeset can be created to update the bus records. The group requested flexibility of the order of columns and ability to hide data from data submitter view screens. The group continued to discuss the current status of the 2020 series MDWG model build including the next posting.

AGENDA ITEM 9A – MDWG POWERFLOW UPDATE

AGENDA ITEM 9B – MDWG SHORT CIRCUIT UPDATE

Michael Odom provided an update on the Pass 1 Trial 1 posting scheduled for November 15th, 2019. Michael outlined the model build issues encountered so far including collecting data from external resources.

AGENDA ITEM 9C – 2021 ITP LOAD AND GENERATION REVIEW UPDATE

Liz Gephardt presented the 2021 ITP load and generation review update. Including upcoming milestones and key stakeholder feedback opportunities. The group discussed how aux loads are modeled. Liz mentioned they are netted out to represent the Pnet of the unit and the unit and load. OKGE mentioned that not all entities will have their final load profiles by the stakeholder review period.

AGENDA ITEM 10 – GEOMAGNETIC DISTURBANCE DATA TPL-007-3 UPDATE

Scott Jordan presented an update to the group about the Geomagnetic Disturbance Data (GMD) in accordance with NERC TPL-007-3. Scott mentioned there would be an updated posting by the end of the year for R5 & R9 requirements. Scott discussed the plan forward to meet with TPLTF for the new GIC number and recently encountered issues with transformer data.
AGENDA ITEM 11 – ITP GENERATOR RETIREMENT RR 384 DISCUSSION

Michael Odom presented the background and overview for the generator retirements and RR discussion. WAPA asked about the implementations of this process and how it relates to the shortfall. Chris mentioned it is a decoupled process for Attachment O and transmission service. The group talked about the must run units. Michael mentioned that the Generator retirement RR might be better suited for that question as RR 384 only addresses how the unit’s parameters are modeled. The group continue their discussion about aux loads considerations as part of the RR. Staff mentioned MDWG manual language can be reviewed and updated to address the concern.

AGENDA ITEM 12 – 2019 INVERTER BASED GENERATION INTEGRATION STUDY

Doug Bowman presented the 2019 inverter based generation integration study results including, transient and small signal stability analysis, short circuit ratio (SCR) analysis, electromagnetic transient (EMT) analysis, and recommendations. The group discussed the presentation and recommendations. SPS asked about the confidential requirement for the PLL gain information. Doug mention it is difficult to gather this data. The group discussed the impacts of the SCR with high wind penetrations. As a next step, the group would like to see timelines and potential costs for the PLL gain data gathering.

AGENDA ITEM 13 – BREAK

The group took a 15-minute break.

AGENDA ITEM 14 – 2020 MDWG PROPOSED MEETING & WORKSHOP SCHEDULE

The group reviewed the proposed 2020 MDWG meeting & workshop schedule. The group discussed the dates as proposed for MDWG and how they correspond to TWG and ESWG meeting schedules.

AGENDA ITEM 15 – MDWG MANUAL TASK FORCE

AGENDA ITEM 15A – EMERGING TECHNOLOGY MODELING PRACTICES

Michael Odom present the recent MDWG manual changes pertaining to emerging technologies. The group review the draft language and provided additional language for consideration. The group reviewed the language for active power, reactive power capabilities, aggregated or utility scale storage or distributed energy resources. MDWG manual task force will continue to develop this language.
AGENDA ITEM 16 – EIPC FREQUENCY RESPONSE EFFORT

AGENDA ITEM 16A – 2019 STUDY UPDATE

Harvey Scribner provided background information and a status update for 2019 EIPC frequency response effort. Harvey described how the low inertia case is being built, assumptions included, and timeline of future milestones. Harvey mentioned the EIPC group is currently discussing how wind farm units can contribute to the inertia calculations.

AGENDA ITEM 16B – APPROACH FOR FUTURE LOW FREQUENCY MODELS

Harvey Scribner outline the current approach for the low inertia case and assumptions included. Harvey mentioned the MMWG would be requesting a case for this as part of the 2021 MDWG modeling efforts. The group discussed timelines and major milestones for this new case requirement. Harvey provided a high-level roadmap for how to utilize the existing Year 5 Light Load case to create the low inertia case including data that will be provided by staff at the beginning of the 2021 series MDWG powerflow build.

AGENDA ITEM 17 – NERC STANDARDS UPDATE

Shannon Mickens provided and NERC standards update to MDWG. Shannon outline the MOD-032-1 SAR edits pertaining to Distributed Energy Resources (DER). Shannon presented the recent NERC Planning Committee (PC) discussions and topics for node-breaker modeling, modeling improvement initiatives, and October Planning Impact for Distributed Energy Resources Working Group (SPIDERWG) meeting notes. Shannon reviewed the TPL-001 SPIDERWG proposed edits and whitepaper that discussed the impacts of DERs on standard requirements.

AGENDA ITEM 18 – BREAK

The group took a 10-minute break.

AGENDA ITEM 19 – EDST UPDATE

Lottie Richardson provided background information for EDST including explanation of the life cycle of a changeset. Lottie recapped recent EDST version 2.0 milestones including bulk update and read only feature. Lottie presented the future enhancements including email notification on postings and scroll bar in changeset displays. The group review the upcoming enhancements. The group provided feedback on email messages. The group mentioned the emails do not provide much information and are sometimes confusing in understanding who the confirming entity, who submitted the changeset, and the name of the changeset. The group talked about best practices for reaching out the other entity prior to sending a transition for confirmation.
AGENDA ITEM 20 – AUTOMATION RELEASE DISCUSSION

Sunny Raheem communicated the business owner and SPP legal disclaimer for sharing the executable version of the SPP DocuCheck and Model Compare automation. Sunny mentioned the automation is being released for model building proposes only as denoted in the disclaimer. Sunny mentioned that Becca McCann has created the executable version of the code and placed it in the MDWG powerflow focus group GlobalScape folder for testing.

**Action Item:** Staff to communicate the GlobalScape path to MDWG.

AGENDA ITEM 21 – ADMINISTRATIVE ITEMS

AGENDA ITEM 21A – SUMMARY OF ACTION ITEMS

The group review the action items.

AGENDA ITEM 21B – FUTURE MEETINGS

Nate Morris outlined the future MDWG, MDWG focus group, and MDWG manual task force meetings

AGENDA ITEM 21C – FUTURE MEETINGS

Nate asked the group if they had any other topics for discussion before the group adjourned. The group did not voice any additional topics.

**Motion:** Reené Miranda motioned to adjourn the meeting. Scott Rainbolt seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at 5:53 pm (MDT).

Respectfully Submitted,

Sunny Raheem

Secretary
Attachments

OCT22_MM_Attach1 - 1e. MDWG Meeting Agenda 20191022-23.docx

OCT22_MM_Attach2 - 1fi. MDWG Minutes September 12, 2019.pdf

OCT22_MM_Attach3 - 1fii. MDWG Minutes September 18, 2019.pdf
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
Xcel Offices, 2nd Floor, Conference Room A
1800 Larimer Street
Denver, Colorado 80202
October 22nd – 23rd, 2019
Face-to-Face
• A G E N D A •
8:30 a.m. – 5:00 p.m. (MDT)
8:30 a.m. – 12:00 p.m. (MDT)

Day 1
1. Administrative Items ................................................................. Nate Morris (15 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. September 12th, 2019 (Approval Item)
      ii. September 18th, 2019 (Approval Item)
   g. Action Items Review
2. Model Build and ITP Study Timelines ......................................................... (15 mins)
3. MDWG Powerflow Focus Group
   a. Staff Dispatch Proposals for MDWG models .......... Jeremy Harris/Lottie Richardson (45 mins)
   b. Node-Breaker Modeling Approach ......................... Jeremy Harris/Lottie Richardson (30 mins)
4. MDWG Short Circuit Focus Group
   a. General Update .......................................................... Reené Miranda/Michael Odom (10 mins)
   b. New DocuCheck ......................................................... Michael Odom/Hugh Benfer (15 mins)
5. Break .............................................................................. (15 mins)
6. MDWG Dynamics Focus Group
   a. General Update .................................................................Marc Moor/Sunny Raheem (10 mins)
   b. 2020 MDWG Dynamic Model Build
      i. Schedule (Approval Item*)..................................................All (30 mins)
      ii. PSSE Version 34.6.1 (Approval Item*).................................All (10 mins)
      iii. Models (Approval Item*)....................................................All (10 mins)
      iv. Acceptable Model Guidelines .............................................Sunny Raheem (30 mins)
7. Lunch .................................................................................................(60 mins)
8. 2019 series MDWG Models Update
   a. Dynamic Models for SPP 2020 TPL........................................Sunny Raheem (5 mins)
9. 2020 series Models Updates
   a. MDWG Powerflow Update .....................................................Lottie Richardson (30 mins)
   b. MDWG Short Circuit Update ....................................................Michael Odom (10 mins)
   c. 2021 ITP Load and Generation Review Update .......................Liz Gephardt (15 mins)
10. Geomagnetic Disturbance Data TPL-007-3 Update ......................Scott Jordan (15 mins)
11. ITP Generator Retirement RR 384 Discussion .................................Michael Odom/David Duhart (30 mins)
12. 2019 Inverter Based Generation Integration Study .........................Doug Bowman (60 mins)
13. Break ...............................................................................................(15 mins)
14. 2020 MDWG Proposed Meetings & Workshop Schedule ..................All (30 mins)
15. MDWG Manual Task Force
   a. Emerging Technology Modeling Practices
      i. Electric Storage Resources ..................................................All (30 mins)
      ii. Distributed Energy Resources ..........................................All (30 mins)
Day 2

16. EIPC Frequency Response Effort ..........................................................................................................
    a. 2019 Study Update ........................................ Harvey Scribner (10 mins)
    b. Approach for Future Low Frequency Models .......... Harvey Scribner (30 mins)

17. NERC Standards Update ............................................................ Shannon Mickens (30 mins)

18. Break ................................................................................................................................. (15 mins)

19. EDST Update ................................................................................................. Lottie Richardson (30 mins)

20. Automation Release Discussion ................................................. Sunny Raheem (10 mins)

21. Administrative Items .................................................................................... Nate Morris (10 mins)
    a. Summary of Action Items
    b. Future Meetings
       i. MDWG
          1. Next Conference Call:
             a. December 5th, 2019 (9:00AM – 12:00PM CST)
             b. Approval Call for 2019 Series MDWG Dynamic Model Set for 2020
                TPL December 13th, 2019 (9:00AM – 11:00AM CST)
          2. Next Face-to-Face: TBD
       ii. Manual Task Force:
          1. Weekly on Thursday 9:00am-11:00am (CST)
       iii. Focus Groups Meetings:
          1. Power Flow & Short Circuit: November 19th, 2019 (9:00AM – 12:00PM CST)
          2. Dynamics: November 13th, 2019 (9:30 – 11:30 AM CST)
    c. Adjourn

Note: The approval items denoted with “**” shall be jointly developed by PC, TP, and MDWG.

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
September 12th: 9:00 A.M. – 12:00 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:01 a.m and was proceeded by Sunny Raheem reading the anti-trust statement.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

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– **Agenda Item 1e(i) – Agenda Review (Approval Item):**
Nate Morris asked the group if they had any modifications to the agenda. The group did not voice any modifications. Nate noted he would like to thank staff in particular Sunny Raheem for gathering background materials in a timely manner.

Jerad Ethridge made motion approve agenda as presented on the screen. Jason Shook seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

**Background Material for Motion:** SEPT12_MM_Attach1 - 1e. MDWG Meeting Agenda 20190912.docx

– **Agenda Item 1f(i) – August 8th, 2019 Meeting Minutes Review (Approval Item):**
Nate Morris asked the group if they had any modification to the August 8th meeting minutes. Sunny Raheem presented the redline changes that staff received since posting the meeting minutes. There was no additional discussion or feedback to the minutes from the group.

**Motion:** Jason Shook made the motion to approve the meeting minutes included the corrections displayed. Scott Schichtl seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

**Background Material for Motion:** SEPT12_MM_Attach2 - 1fi. MDWG Minutes August 8, 2019_redlines.pdf

– **Agenda Item 1g – Action Items Review:**
Sunny presented an overview of the action items and briefly discussed recently completed items. Sunny reviewed staffs’ comments since the last meeting for in-progress action items. There was no additional discussion or feedback to the action items from the group.
Agenda Item 2 – 2019 MDWG Model Series:
- Agenda Item 2a – MDWG Dynamics Model Build Update:
Sunny Raheem provided an update on the 2019 series MDWG models. Sunny mentioned the September 18th approval call and outlined the updates received based on the proposed final model so far.

Agenda Item 3 – MDWG Focus Group Updates:
- Agenda Item 3a – Power Flow Model Build Update:
Lottie Richardson gave an updated on the current 2020 MDWG/2021 ITP powerflow models including an overview of participation levels for MOD-033-1 feedback and DocuCheck updates. The group had a lengthy discussion about MOD-033-1 data and expectations. The group discussed improvements on communication opportunities aside from MOD-032-1 kickoff emails. The group determined an MOD-033-1 results review and education session is warranted. Lottie continued the powerflow updates by mentioning the current Engineering Data Submission Tool (EDST) enhancements and issues. Lottie provided an update on Model On Demand (MOD) issues and hot fixes provided the vendor. Lottie mentioned the vendor provided a MOD patch, which will be pushed out soon.

Action Item: Staff to resend the MOD-033-1 presentation, report, and results.
Action item: Staff to schedule meeting to go over MOD-033-1 meeting.

- Agenda Item 3b – Short Circuit Model Build Update:
Michael Odom provided a quick update on the status of the 2020 series MDWG short circuit models. Michael provided the group an update on the consultant effort for building the 2020 series MDWG short circuit models.

- Agenda Item 3c – Dynamic Model Build Schedule Development Preview:
Sunny Raheem presented the draft 2020 series dynamic model build schedule. Sunny mentioned the draft was presented at the September 11th MDWG dynamic focus group meeting. Sunny mentioned that staff requested an October 11th feedback from the focus group. The group discussed the PSSE version (v34.6.1) that will be utilized in the 2020 dynamic models.
Agenda Item 4 – MDWG Focus Group Updates:
- Agenda Item 4a – Dynamics:
  Marc Moor provided an update on recent meetings. Marc mentioned the group review the EIPC frequency response effort update by staff, 2020 MDWG dynamic case build schedule review, need for model instance standardization, and discussion about EMT simulations.

- Agenda Item 4b – Power Flow:
  Jerad and Jeremy provided an overview of recent MDWG Powerflow Focus Group activities. The group recently discussed automation script sharing, node breaker modeling assumptions, and EDST/MOD updates.

- Agenda Item 4c – Short Circuit:
  Reené Miranda provided an update for the call on August 27th. Reené mentioned Hugh Benfer presented the new short circuit DocuChecks. Reené and Michael Odom mentioned the next MDWG short circuit focus group meeting would be partnered with the powerflow focus group in November. Michael mentioned he is coordinating the meeting times via Doodle poll.

Agenda Item 5 – MDWG Development Procedure Manual (Approval Item*):
Michael Odom presented the recent MDWG manual changes. Michael mentioned the need for approval based on the duplicate generator data section language. The group reviewed the generator data sections and provided feedback for updating the language.
Steve Holman provided feedback for the MDWG manual. The group reviewed the renewable dispatch and provided edits during the meeting. The group discussed if the manual should be reposted at v3.0 or if it should be posted as v3.1. As a result of the discuss the group decided to post the materials at v3.1

Motion: Steve Hohman made the motion to approve the MDWG Manual with the edits displayed on the screen as version 3.1 and updating the 2020 series MDWG power flow and short circuit schedule. Andy Berg seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

Background Material for Motion: SEPT12_MM_Attach3 - 5. SPP Model Development Procedure Manual 2019 v3.0_PENDING_Updated.docx

Agenda Item 6 – Break
The group took a 10 minute break.
**Agenda Item 7 – MDWG Charter/Scope Approval (Approval Item):**
Sunny Raheem presented the MWDG Scope revisions for approval. Sunny mentioned the edits are in part of the annual scope review. In addition, the edits are to meet an action item from SPP Corporate Governance Committee (CGC) for scope standardization in accordance with SPP scope template and bylaws. The group reviewed the changes and did not voice any additional concerns.

**Motion:** Andy Berg made the motion to approve the MDWG Scope as revised. Alex Mucha seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

**Agenda Item 8 – Joint SPC/MOPC Briefing HITT Initiatives:**
Casey Cathey presented the group a debriefing of the SPC/MOPC HITT initiatives that are particular to transmission planning and consideration of future model development efforts. Casey provided a high-level overview of the 21 recommendations that are split out into four categories, Reliability, Marketplace, Transmission Planning & Cost Allocation, and Strategic. The Planning and Cost Allocation recommendations included NRIS/ERIS modifications, Uniform schedule 9 local planning criteria, new load addition modifications, three-phase GI process effectiveness, B/C ratio for economic projects, decouple schedule 9 & 11 pricing zones, byway cost allocations review process, eliminate z2 revenue crediting, and cost allocation for transmission storage. The group discussed the potential impacts to transmission planning models because of the HITT initiatives and timelines associated with the task forces created to carry out the recommendation to completion.

**Agenda Item 9 – ITP Quarterly Report Card:**
Sherri Maxey presented the 2019, 2020, and 2021 ITP quarterly assessment report card. Sherri provided a description of the status legend slide. Sherri provided the group an overview of the current and upcoming milestones pertaining to 2019, 2020, and 2021 ITP assessments.
**Agenda Item 11 – Administrative Items:**

- **Agenda Item 11a – Summary of Action Items:**
  - Staff to resend the MOD-033-1 presentation, report, and results.
  - Staff to schedule meeting to go over MOD-033-1 meeting.

- **Agenda Item 11b – Future Meetings:**
  Nate provided an overview of future meetings.

- **Agenda Item 11c – Adjourn Meeting:**
  Nate opened the floor to entertain a motion for approval.

**Motion:** Scott Schichtl made the motion to adjourn the meeting. Alex Mucha seconded it. The motion passed unanimously.

The meeting adjourned at 11:46 AM (CDT).

Respectfully submitted,
Sunny Raheem
MDWG Secretary
Agenda Item 1 – Administrative Items:

– **Agenda Item 1a and 1b – Call to Order & Antitrust Statement:**
The meeting was called to order at approximately 1:02 p.m and was proceeded by Sunny Raheem reading the anti-trust statement.

– **Agenda Item 1c and 1d – Attendance and Proxies:**
The following MDWG members and guests attended.

**MDWG Members present:**

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- **Agenda Item 1e(i) – Agenda Review (Approval Item):**
  Nate Morris asked the group if they had any modifications to the agenda. Sunny Raheem mentioned that he had a typo correction for agenda item 7. The group did not voice any modifications.

  Nate opened the floor to entertain a motion for approval of the updated meeting agenda.

  Jason Shook made move to adopt the edited agenda as presented on the screen. Jordan Lamb seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

  **Background Material for Motion:** AUG08_MM_Attach1 - 1e. MDWG Meeting Agenda 20190808_redline.docx

- **Agenda Item 1f(i) – July 11th, 2019 Meeting Minutes Review (Approval Item):**
  Nate Morris asked the group if they had any modification to the July 11th meeting minutes. There was no additional discussion or feedback to the minutes from the group.

  Nate opened the floor to entertain a motion for approval.

  **Motion:** Joe Fultz made the motion to approve the previous meeting minutes. Jason Shook seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

  **Background Material for Motion:** AUG08_MM_Attach2 - 1fi. MDWG Minutes July 11, 2019.pdf

- **Agenda Item 1g – Action Items Review:**
  Sunny presented an overview of the action items and briefly discussed recently completed items. Sunny reviewed staffs’ comments since the last meeting for in-progress action items. Michael Odom provided an update for the short circuit data request (action item #2). Michael mentioned the data request has been sent to MISO Transmission Owner (TO) and now SPP staff is waiting on MISO TO to provide information. Nate Morris requested continual updates on action items that have been in progress for a while. There was no additional discussion or feedback to the action items from the group.
**Agenda Item 2 – MDWG Focus Group Updates:**

**– Agenda Item 2a – Dynamics:**
Marc Moor provided a quick update on recent meetings. Marc recapped the June MDWG workshop discussion about value provided and importance of synchronous vs non-synchronous machine speed and angle. Marc outlined the meeting times for upcoming meetings. Marc worked with other interested parties to review the proposed MDWG manual language change for machine z-source impedance and generator modeling.

**– Agenda Item 2b – Power Flow:**
Jerad Ethridge provided an update on recent meetings. Jerad mentioned Moses provided a MOD file builder demo in PSSE v34.6.1. Jerad reviewed the shunt data request sent out by MDWG power flow focus group and staff. The group discussed how to determine the control type based on the instructions provided. The group discussed how members could gather the information request. The group mentioned each shop’s control systems group is a good starting point. Jerad and Moses reminded the group of the deadline for the shunt data request of Friday October 18th deadline. Jerad mentioned that he is stepping down on leading the power flow focus group with his new Vice Chair responsibility. Jeremy Harris will be leading the power flow focus group going forward. Jerad mentioned the MDWG power flow focus group is always open for any new topics for discussion. Nate Morris mentioned that he would like to reiterate if the group would like to present any new topics.

**– Agenda Item 2c – Short Circuit:**
Reené Miranda provided an update on the recent MDWG short circuit meeting including upcoming meetings and topics. Reené mentioned that group is discussing the shunt modeling information and future short circuit model docuchecks. Reené provided an overview of upcoming short circuit focus group meetings.
**Agenda Item 3 – Electric Storage Projects Overview Education Session:**
Jeff Plew provided a history of NextEra’s electric storage resources. Jeff provided an overview of market landscape, technology update and applications, solar/storage coupling design options, and Bulk Electric System inverters. For market landscape, Jeff presented the various types of application such as grid services, demand charge management, back-up power, renewable firming, and demand response. Jeff outlined the driving reasons for energy storage installation increases. Jeff discussed key terminology, typical configuration, integration of energy storage, battery degradation factors, and applications based on duration. Jeff spoke about the various different storage and other renewable resource site coupling on the DC and AC connections. The group thanked Jeff for presenting NextEra energy resources overview of electrical storage devices.

**Agenda Item 4 – Break**
The group took a 10 minute break.

**Agenda Item 5 – 2020 MDWG Model Series**
- **Agenda Item 5a – Power Flow & Short Circuit Model Build Update:**
Moses Rotich started the power flow and short circuit model build update by answering some commonly asked questions he received since the last MDWG meeting. Moses mentioned that EDST is locked at the same time as MOD to ensure staff can build the models with data submitted by the deadline. Additionally, this gives SPP IT an opportunity to push hot fixes/corrections during the lockout period. Moses mentioned that some data submitters have noticed issues with MOD when uploading profiles and projects. Data submitters mentioned that they can upload a profile or project one minute with issues and then the next time it does not have issues uploading. Moses mentioned he reached out to Siemens PTI about this issue. Siemens mentioned that they tested MOD v10 on a different version than what is installed on SPP servers. SPP IT mentioned it would be a large impact to change the Oracle server version citing security concerns. Moses mentioned that Siemens PTI will look into a hot fix for the Oracle version has SPP has installed.

Moses provided the group with instructions on how to reset passwords for GlobalScape via RMS ticket. Moses presented the hyperlink enhancements DocuCheck. Moses gave kudos to Hugh Benfer and Becca McCann for the code updates. Moses presented the group with the updated data submission template for non-PSSE users. The purpose of the template is to standardize the data submission for non-PSSE users and allow staff to have an automated way to create the response files for inclusion into the models.

The group discussed the release timing of the renewable dispatch and the December 13th deadline for MOD-033-1 unacceptable differences.

SPS asked about the status of Generator Owner (GO) updates in the 2019 series dynamic models. Staff mentioned for future communication SPP can include the Transmission Planning (TP) in the data request and follow up communication.
– Agenda Item 5b – PSSE Version Change to V34.6 (Approval Item):
Moses Rotich provide an overview to the group for the PSSE version change approval agenda item. Moses mentioned some members and staff have discovered issues with the previously approved PSSE version 34.5.1. Members of group chimed in on the issues that they have experience since the start of the model build. Some members mentioned that they have already started the process of moving to PSSE v34.6.1. Nate Morris took his chair hat off and mentioned Empire District has discovered issues and would like to move to PSSE 34.6 or subversion of it.

The group discussed the process if issues are discovered in PSSE 34.6. Moses mentioned that staff would work with Siemens PTI to develop hot fixes when possible. Some members of the group mentioned that their IT groups might take some time for the new PSSE version install. The group discussed if the data submission format was different between PSSE v34.5 and v34.6. Staff mentioned that they believe the format between the two versions was the same.

Nate opened the floor to entertain a motion for approval.

Motion: Jordan Lamb made the motion to approve the PSSE version change v34.6 and update the posted approved MDWG model build schedule. Jason Shook seconded motion. During discussion of the motion, the group discovered that Siemens PTI recently removed PSSE version v34.6.0 from their website for availability. As a result, no members voted in favor of the motion. All members opposed. Motion did not pass.

Nate opened the floor to entertain a motion for approval of a different PSSE version of 34.6.

Motion: Jordan Lamb made the motion to move to PSSE version change v34.6.1 and update the posted approved MDWG model build schedule. Liam Stringham seconded motion. The motion passed unanimously.

Action Item: Staff to repost the 2020 series Powerflow and Short Circuit Schedule with the updated PSSE version.
Agenda Item 6 – MDWG Manual Language (Approval Item*):
Michael presented the latest MDWG manual changes including transformer section and general updates as part of version 3.0 of the manual. Marcus Moor presented an updated on the recent activity for machine impedance values. Michael presented the tap positions of transformers including discussion around maximum and minimum tap positions. The group discussed the number of taps at length. The group talked about the amount of work required to meet the transformer language update requirement.

Eddie Watson asked staff and the manual task force if there was a need to record the reason why some language was removed and how it was replaced. Staff mentioned they would look at providing a comparison in the near future.

The group reviewed the language update around the dynamic model acceptable model list and provided edits during the meeting. Afterwards, the group reviewed the language modification around the TPL outages. Finally, the group reviewed the updated generator retirement model requirements language. Michael mentioned the updated language for generator retirements provides additional security to avoid pointing out retirement within the model based on the previous MDWG manual language.

Nate opened the floor to entertain a motion for approval.

Motion: Reené Miranda made the motion to approve the edits in the MDWG manual procedure document v3.0. Jason Shook seconded the motion. The motion passed unanimously.

Michael thanked the manual task force participants for all their help. The group thanked Michael for his effort. Eddie seconded the thanks to the group and Michael.

Action Item: Michael to provide language comparison between the manual versions.

Background Material for Motion: AUG08_MM_Attach3 - 6. SPP Model Development Procedure Manual 2019 v3.0_Working_Latest_Update.docx
Agenda Item 7 – 2019 MDWG Model Series:
- Agenda Item 7a – MDWG Dynamics Model Build Update:
Sunny Raheem provided a quick update on the 2019 series MDWG dynamic model build. Sunny mentioned members’ final data submission is due August 12th. Staff will work on building the final dynamic models after the deadline and should be on schedule for the August 27th posting. Sunny mentioned after the final MDWG models are build, staff would start working on the 2020 TPL models in accordance with the approved model build schedule. The group discussed the level of GO and TP participation.

Agenda Item 8 – Administrative Items:
- Agenda Item 8a – Summary of Action Items:
  - Staff to repost the 2020 series Powerflow and Short Circuit Schedule with the updated PSSE version.
  - Michael to provide language comparison between the manual versions.

- Agenda Item 8b – Future Meetings:
Nate provided an overview of future meetings.

- Agenda Item 8c – Adjourn Meeting:
Nate opened the floor to entertain a motion for approval.

Motion: Jason Shook made the motion to adjourn the meeting. Alex Mucha seconded it. The motion passed unanimously.

The meeting adjourned at 4:02 PM (CDT).

Respectfully submitted,
Sunny Raheem
MDWG Secretary
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
August 8th, 2019
Conference Call
• A G E N D A •
1:00 p.m. – 4:00 p.m. (CDT)

1. Administrative Items ........................................................................................................... Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. July 11th, 2019 (Approval Item)
   g. Action Items Review

2. MDWG Focus Group Updates
   a. Dynamics .................................................................Marc Moor/Sunny Raheem (5 mins)
   b. Power Flow ............................................................Jerad Ethridge/Moses Rotich (5 mins)
   c. Short Circuit .........................................................Reené Miranda/Michael Odom (5 mins)

3. Electric Storage Projects Overview Education Session ............................................NextEra Resources (65 mins)

4. Break .................................................................................................................................. (10 mins)

5. 2020 MDWG Model Series
   a. Power Flow & Short Circuit Model Build Update .........................Moses Rotich (20 mins)
   b. PSSE Version Change to V34.6 (Approval Item) ......................Moses Rotich (10 mins)

6. MDWG Manual Language Approval (Approval Item*) ........................................Michael Odom (30 mins)

7. 2020-2019 MDWG Model Series
   a. MDWG Dynamics Model Build Update ..........................Sunny Raheem (10 mins)

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
9. Administrative Items ............................................................................................................ Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Next Conference Call: September 12th (9:00am – 12:00pm)
         2. Next Face-to-Face: Xcel Office, Denver, CO October 22-23rd
      ii. Manual Task Force:
         1. Weekly on Thursday 9am-11am
      iii. Focus Groups Meetings:
         1. Power Flow: August 12th (9:30am –11:30am)
         2. Dynamics: August 14th (9:30am –11:30am)
         3. Short Circuit: August 27rd (9:00am –11:00am)
   c. Adjourn

Note: The approval items denoted with “***” shall be jointly developed by PC, TP, and MDWG.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
July 11th: 9:00 A.M. – 12:00 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:01 a.m and was proceeded by Sunny Raheem reading the anti-trust statement.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

**MDWG Members present:**

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<thead>
<tr>
<th>MDWG Member</th>
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<td>Western Area Power Administration</td>
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– Agenda Item 1e(i) – Agenda Review (Approval Item):
Nate Morris asked the group if they had any modifications to the agenda. The group did not voice any modifications.

Nate opened the floor to entertain a motion for approval of the updated meeting agenda.

Jerad Ethridge made the motion to approve the agenda. The group did not voice concern during the discussion of the motion. Andy Berg seconded the motion. The motion passed unanimously.

Background Material for Motion: JUL11_MM_Attach1 - 1e. MDWG Meeting Agenda 20190711.docx

– Agenda Item 1f(i) – June 6th, 2019 Meeting Minutes Review (Approval Item):
Nate Morris asked the group if they had any modification to the June 6th meeting minutes. There was no additional discussion or feedback to the minutes from the group.

Nate opened the floor to entertain a motion for approval.

Motion: Scott Rainbolt made the motion to approve the June 6th meeting minutes as shown on the screen. The group did not voice concern during the discussion of the motion. John Boshears seconded the motion. The motion passed unanimously.

Background Material for Motion: JUL11_MM_Attach2 - 1fi. MDWG Minutes June 6, 2019.pdf

– Agenda Item 1g – Action Items Review:
Sunny presented an overview of the action items and briefly discussed recently completed items and those to be covered during the meeting. Michael Odom provided an update for the short circuit data request (action item #2) to MISO and mentioned that staff is sending out the SPP external short circuit data request within the next week. Sunny provided an update to the group on the status for action item #47 and #53 since posting the background material for this meeting. There was no additional discussion or feedback to the action items from the group.
**Agenda Item 2 – 2020 MDWG Model Series**

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**Agenda Item 2a – Power Flow & Short Circuit Model Build Kickoff Discussion:**

Moses Rotich reviewed the 2020 Series Model Build Kick-off email including the next steps for data submitters, reminders, and instruction and supplemental information. Moses provided reminders on how to get access to GlobalScape, Engineering Data Submission Tool (EDST), and RMS. The group review the 2020 Series MDWG power flow and short circuit model build schedule.

Moses Rotich and Clayton Mayfield presented two new DocuCheck automation checks. Clayton presented the purpose of the red check for BR retirement conflicts based on machine $P_{\text{max}}$, $P_{\text{min}}$, $Q_{\text{max}}$, and $Q_{\text{min}}$ case parameter settings. Clayton presented the description for each column in the BR retirement conflicts spreadsheet tab with example data populated. Exceptions for synchronous condensers, DVARs were presented. The group discussed other exceptions types that should be added to the list. Clayton presented the information check for ITP BR Retirements. Staff asked if the group had any questions. Some in the group mentioned a trial run would help trigger any additional questions or proposed modifications to the two new checks.

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**Agenda Item 2b – Workshop Survey Results:**

Sunny Raheem presented the summary of the workshop survey results. Sunny presented the rating questions results from thirty survey participants. Sunny mentioned the majority of the feedback seemed positive and indicated the workshop was considered successful based on survey participant feedback. Sunny continued by presented the open-ended survey results and summarized that majority of the open-ended comments suggested more hand-on demos be available at the next workshop.

Nate Morris communicated his appreciation for model builders and staff for participating in the model build event. Nate mentioned the workshop seemed to receive a positive review and he looks forward to seeing the enhancements in the next workshop.

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**Agenda Item 3 – NERC SPIDERWG Update**

Shannon Mickens, from SPP RTO Reliability Standards Department, presented the group an update for NERC System Planning Impacts from Distributed Energy Resources Working Group (SPIDERWG). Shannon provided background information for SPIDERWG. Shannon discussed the deliverables from previous SPIDERWG meetings including the DER_A dynamic model reliability guideline description and current status, and MOD-032-1 Standard Revision for inclusion of UDERs and RDERs. Shannon summarized the SPP Planning strategic approach starting with sending out a Load Responsibility Entity (LRE) survey to understand the quantity of known DERs in the SPP footprint. Shannon presented the future SPIDERWG meetings include the July 24-25, 2019 meeting in Salt Lake City, UT and October 8-9, 2019 meeting in Chicago, IL. Some in the group mentioned that they are participating in SPIDERWG as well. Nate Morris thanks Shannon for provided the SPIDERWG update.
Agenda Item 4 – Break
The group took a 10 minute break.

Agenda Item 5 – MDWG Manual Language Approval (Approval Item*)
Michael Odom presented the recent MDWG manual task force proposed revisions for the MDWG manual. Michael walked through the redline changes in Section 1: Introduction for subsection Applicable Data Submitters. The group reviewed the changes in the Applicable Data Submitters section and provided a modification to the proposed language. Michael presented the language updates for transformer taps, tap limits, and connection codes in Section 3 Steady-State Data Requirements subsection Line and Transformer Data. Afterwards, Michael presented the changes to the generator requirements under Section 3: Steady-State Data Requirements. Michael communicated this change is proposed from the MDWG dynamic focus group with consideration of additional input from Evergy and OPPD. Staff noted the purpose of the generator requirement language updates is to provide clarification on Z-source parameters for various typical types of generators. Under Other Device subsection, the changes to required information for transformers, impedance data, and number of tap positions (for both the ULTC and NLTC) were presented. The group discussed the changes to the generator, transformers, impedance data, and number of tap positions at length. The group suggested that the MDWG manual task force should review the transformer tap changes.

Nate opened the floor to entertain a motion for approval.

Motion: Andy Berg made the motion to approve the MDWG manual updates as presented except for the tap position related to NLTC, which will go to the MDWG Manual Task Force for further language development. The group did not voice concern during the discussion of the motion. John Boshears seconded the motion. The motion passed unanimously.

Background Material for Motion: JUL11_MM_Attach3 - 5. SPP Model Development Procedure Manual 2019 v2.5_Pending_Updated.docx

Agenda Item 6 – MDWG Membership Nomination Announcements:
– Agenda Item 6a – Vice Chair Position (Approval Item):
Nate Morris reminded the group of the recent MDWG Vice-Chair resignation. Nate mentioned he has been soliciting the Vice-Chair position on an individual basis. Nate mentioned he had a candidate that has been leading, participating, providing input, and sharing knowledge at a high level within the MDWG working group and focus groups. Nate mentioned this candidate, Jerad Ethridge, has also received a great reference from staff as well. The group did not voice any concerns with Jerad Ethridge as the Vice-Chair nomination.

Nate opened the floor to entertain a motion for approval.

Motion: Reené Miranda motioned to approve Jerad Ethridge as Vice Chairman of MDWG. Alex Mucha seconded the motion. The motion passed unanimously.
-- Agenda Item 6b – Open Voting Positions Update:
Nate Morris provided an updated on the current voting membership at MDWG. Nate mentioned that Derek Brown (Evergy Companies & MDWG Vice-Chair) and Dustin Betz (Nebraska Public Power District) resigned from their voting seats to focus their participation in other SPP working groups. Nate mentioned staff received six nominations during the solicitation period. Nate and Sunny have reviewed the nomination and started the process of seeking SPP management approval in accordance with the SPP bylaws. Once the nominations are approve Sunny will communicate the voting membership results to MDWG.

Action Item: Sunny to updated MDWG via email on MDWG membership nomination and selection

Agenda Item 7 – 2019 MDWG Dynamics Model Build Update:
Sunny Raheem provided a quick updated on the status of the 2019 MDWG dynamic model build. Sunny mentioned that staff will posting the initial models on 7/22/2019 with next step instructions on data modified for cases to initialize flat.

Agenda Item 8 – MDWG Focus Group Updates:

-- Agenda Item 8a – Dynamics:
Sunny Raheem provided a quick update on future meetings including upcoming meetings and topics. Sunny mentioned the July meeting is cancelled to allow staff and members additional time for the 2020 MDWG power flow build and reviewing the 2019 MDWG initial dynamic models.

-- Agenda Item 8b – Power Flow:
Jerad Ethridge provided a quick update on future meetings including upcoming meetings and topics. Jerad mentioned the group discussed a testing plan for benchmarking shunt modeling as proposed in MDWG manual redline revisions.

-- Agenda Item 8c – Short Circuit:
Reenée Miranda provided an update on the recent MDWG short circuit meeting including upcoming meetings and topics.

Agenda Item 9 – Administrative Items:
- Agenda Item 9a – Summary of Action Items:
  • Sunny to updated MDWG via email on MDWG membership nomination and selection
  • Sunny to email updated WebEx for each call for the rest of 2019

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
- **Agenda Item 9b – Future Meetings:**
  Nate provided an overview of future meetings.

- **Agenda Item 9c – Adjourn Meeting:**
  Nate Morris asked the group if there was anything else they would like to discuss before adjourning. Sunny Raheem mentioned that SPP has recently switched to a new WebEx provider and it will affect previous scheduled meeting dial-in and URL information. Sunny mentioned the SPP event page for the meeting would contain the updated dial-in information and URL; however, member’s local personal calendars will still have the old information. Sunny mentioned he would try to send out the updated information one hour before each meeting for the rest of the year.

  **Action Item:** Sunny to email updated WebEx for each call for the rest of 2019

  Nate opened the floor to entertain a motion for approval.

  **Motion:** Jerad Ethridge made the motion to adjourn the meeting. Andy Berg seconded it. The motion passed unanimously.

  The meeting adjourned at 11:40AM (CDT).

  Respectfully submitted,
  Sunny Raheem
  MDWG Secretary
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
July 11th, 2019
Conference Call
• A G E N D A •
9:00 a.m. – 12:00 p.m. (CDT)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. June 6th, 2019 (Approval Item)
   g. Action Items Review
2. 2020 MDWG Model Series
   a. Power Flow & Short Circuit Model Build Kickoff Discussion ............ Moses Rotich (30 mins)
   b. Workshop Survey Results ......................................................... Sunny Raheem (15 mins)
3. NERC SPIDERWG Update ......................................................... Shannon Mickens (15 mins)
4. Break ......................................................................................... (5 mins)
5. MDWG Manual Language Approval (Approval Item*) ......................... Michael Odom (60 mins)
6. MDWG Membership Nomination Announcements
   a. Vice Chair Position (Approval Item) ............................................ Nate Morris (10 mins)
   b. Open Voting Positions Update ................................................... Nate Morris (5 mins)
7. 2019 MDWG Dynamics Model Build Update ................................. Sunny Raheem (5 mins)
8. MDWG Focus Group Updates
   a. Dynamics ........................................................................ Marc Moor/Sunny Raheem (5 mins)
   b. Power Flow ........................................................................ Jerad Ethridge/Moses Rotich (5 mins)
   c. Short Circuit ......................................................................... Reené Miranda/Michael Odom (5 mins)
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9. Administrative Items .................................................................................................................. Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Next Conference Call: August 8th (1:00pm – 4:00pm)
         2. Next Face-to-Face: Denver, CO October 22-23rd
      ii. Manual Task Force:
         1. 2nd, 3rd, and 4th Thursday of each month 9am-11am
      iii. Focus Groups Meetings:
         1. Power Flow: July 15th (9:30am –11:30am)
         2. Dynamics: August 14th (9:30am –11:30am)
         3. Short Circuit: July 23rd (9:00am –11:00am)
   c. Adjourn

Note: The approval items denoted with “***” shall be jointly developed by PC, TP, and MDWG.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
June 6th: 9:00 A.M. – 12:00 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:02 a.m and was proceeded by Sunny Raheem reading the anti-trust statement.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

**MDWG Members present:**

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<td>Clayton Mayfield, David Duhart, Eddie Watson, Hugh Benfer, Leah Coffield, Lottie Richardson, Jennifer Swierczek, Jonathan Hayes, Kim Farris, Michael Odom, Moses Rotich, Shahrokh Akhlaghi</td>
<td>Southwest Power Pool, Inc.</td>
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<td>Aravind Chellappa, Frank Favela</td>
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<td>Western Area Power Administration</td>
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<td>Joe Williams</td>
<td>Western Farmers Electric Cooperative</td>
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– Agenda Item 1e(i) – Agenda Review (Approval Item):
Nate Morris asked the group if they had any modifications to the agenda. The group did not voice any modifications.

Nate opened the floor to entertain a motion for approval of the updated meeting agenda.

Derek Brown made the motion to approve the agenda as presented on the screen. The group did not voice concern during the discussion of the motion. Jason Shook seconded the motion. The motion passed unanimously.

Background Material for Motion: JUN06_MM_Attach1 - 1e. MDWG Meeting Agenda 20190606.docx

– Agenda Item 1f(i) – June 6th, 2019 Meeting Minutes Review (Approval Item):
Nate Morris asked the group if they had any modification to the June 6th meeting minutes. Sunny Raheem presented redlines staff received by MDWG members for typo corrections under Agenda Item 1g – Action Items Review. Sunny Raheem presented the redlines and asked the group if there are any additional modifications or questions. There was no additional discussion or feedback to the minutes from the group.

Nate opened the floor to entertain a motion for approval.

Motion: Jason Shook made the motion to approve the June 6th meeting minutes as shown on the screen. The group did not voice concern during the discussion of the motion. Jerad Ethridge seconded the motion. The motion passed unanimously.

Background Material for Motion: JUN06_MM_Attach2 - 1f. MDWG Minutes May 20, 2019_redlines.pdf
**Agenda Item 1g – Action Items Review:**
Sunny presented an overview of the action items and briefly discussed recently completed items and those to be covered during the meeting. Staff provided an update for the short circuit data request (action item #2) to MISO and mentioned that staff is sending out the SPP external short circuit data request within the next week. Staff also mentioned action item #42 would be discussed during the meeting. The group reviewed the action item list and added action item #46. There was no additional discussion or feedback to the action items from the group.

**Agenda Item 2 – MDWG Face-to-Face Meeting Discussion**
Nate Morris introduced the MDWG Face-to-Face meeting discussion. Nate provided an overview of the planned October 2019 face-to-face and scheduled November 2019 face-to-face meeting per the 2020 MDWG power flow schedule. The group discussed the need for one face-to-face meeting as opposed to two face-to-face in the October and November. The group conducted a straw poll of members and participates for 1) October only meeting in Denver CO, 2) October meeting in Denver CO and November meeting in Little Rock AR, 3) November only meeting in Little Rock AR. The group discussed the three options and majority decided on option #1. Nate and Sunny agreed to discuss the November face-to-face meeting need offline for a recommendation to the group as part of the 2020 MDWG power flow schedule.

**Action Item:** Nate and Sunny to discuss the November face-to-face meeting need.
Agenda Item 3 – MDWG Manual Language: 
– Agenda Item 3a – MOD Matrix Submittal (Approval Item*):
Moses Rotich provided an overview of the Model on Demand (MOD) Matrix and the three options. Moses provided a summary of how three options were developed. Moses mentioned the MDWG Powerflow focus group and staff worked on three version. Moses mentioned the current projects would not require a mitigation unless the data submitter changes the types and statuses. In agreement with majority of the MDWG power flow focus group, Moses communicated staff’s recommendation for seeking approval for Option 3 in the MOD Matrix spreadsheet.

The group discussed the need for submitting projects that are not included in any SPP planning models. Moses mentioned those types of projects can be stage in MOD while the data submitter waits on the approval of the study/agreement to complete. The status of the project will have to be updated. The group discussed how the previous NERC compliance Moses mentioned the Planned Transmission System Change will be the new category. The group discussed the meaning behind “Acknowledgement” in the MOD matrix. The group asked if staff could change the status for Planned Transmission System Change – Acknowledged Status tag.

Derek Brown provided additional background information on FAC-002-2 needs being addressed by the proposed MOD matrix. Derek mentioned how he understood the proposed current day process for changing from “requested” to “acknowledged”. Derek mentioned that he understands that the framework is what we are approving today and not the SPP evaluation study process for Local Planning Criteria (LCP) or Local Planning Process (LPP). If SPP LCP or LPP processes are approved then further evaluation and study process would be required. Review of the MOD matrix will be required at that time also. Staff agreed with Derek’s understanding. Scott Rainbolt mentioned he is okay with the framework but has reservations on including items in the SPP planning models that have not approved by MDWG, TWG, and other parties dependent on the models.

Nate opened the floor to entertain a motion for approval.

Motion: Derek Brown move to approve the Option 3 MOD Matrix as the MOD Matrix type/status matrix. The group did not voice concern during the discussion of the motion. Jason Shook seconded the motion. The motion passed with one abstention.

Scott Rainbolt provided his reasoning for abstaining, as “I believe MDWG has jumped the gun on the material modification discussion that is ongoing in the TWG and other groups. I’m highly concerned about some of the projects described “Planned Transmission System Change” category being applied to all cases. A TO can have many discretionary projects that they want to do and even budget for that can be stopped before construction or even halted during construction due to unforeseen budget issue. At times, those projects may not be restarted for several years. I don’t believe some of the types of projects listed should be added to all cases.”

Background Material for Motion: JUN06_MM_Attach3 - 3a. DRAFT - Simplified Mod Project Type-Status Matrix_cc_SPP_PFFG.xlsx
- Agenda Item 3b – Language Approval (Approval Item*):
  Michael Odom presented the latest changes to the MDWG manual from the MDWG manual task force. Michael presented the revision history, footnote removal in the applicable equipment section, clarification and removals in Section 3 Steady State Data Requirements for Engineering Data Submission Tool to account for the latest business practice, redlines for Load Forecasting & Bus Data, generator data section, shortfall guidance process, external resource modeling. The group requested to table the Z-source changes for the generator data section to further discuss the accuracy if AC or DC armature resistance should be reported as part of the generator data. The group also discussed the shunt language revisions will need additional discussion at the power flow focus group.

  **Action Item:** MDWG power flow focus group to develop the shunt device testing plan and work. Staff to bring planning concerns to the power flow focus group.

  **Action Item:** Members to provide additional feedback for DC armature resistance.

  Nate opened the floor to entertain a motion for approval of items covered and not including the shunt or Z-source language additions.

  **Motion:** Reené Miranda made the motion to approve manual changes as presented. Jason Shook seconded the motion. Motion passed

  Background Material for Motion: JUN06_MM_Attach4 - 3b. SPP Model Development Procedure Manual 2019 v2.4_Working_Pending_Updated.docx

  **Agenda Item 4 – Break:**
  The group took a 10 minute break.

  **Agenda Item 5 – Membership Nomination Announcements:**
  Nate Morris provided the group an update on the MDWG Scope voting seat expansion. Nate communicated the MDWG Scope has been approved by SPP MOPC and Board of Directors. Nate mentioned that Sunny would be soliciting for nominations after this meeting to the SPP MOPC representatives.

  **Action Item:** Sunny to send new voting member solicitation to MOPC after meeting.

  **Agenda Item 6 – Node-Breaker Release Discussion:**
  Moses Rotich introduced the Node-Breaker release topic. Staff requested feedback from the group on if they had any restrictions for releasing the SPP developed EHV node breaker model. The group discussed the benefits and considerations of releasing the node-breaker data as a whole and by entity. The group concluded that the information would be released as a whole when the full node-breaker model is developed, so the group was in agreement with releasing as a whole for the SPP developed model.

  **Action Item:** Staff release SPP developed EHV Node-Breaker model with the next week on GlobalScape.
Agenda Item 7 – 2019 MDWG Dynamics Model Build Update:
Sunny Raheem provided a quick updated on the status of the 2019 MDWG dynamic model build. Sunny mentioned that staff is behind one week in the build in part due to the late finalization of the MMWG models. Staff believed they could mitigate the week of work with the current schedule.

Agenda Item 8 – MDWG Focus Group Updates:

– Agenda Item 8a – Dynamics:
MDWG dynamic focus group provided a quick update on future meetings.

– Agenda Item 8b – Power Flow:
MDWG power flow focus group provided a quick update on future meetings.

– Agenda Item 8c – Short Circuit:
Reené Miranda provided an update on the recent MDWG short circuit meeting. Reené mentioned the group thanked Kalen Coleman for the short circuit presentation.

Agenda Item 5 – Administrative Items:
- Agenda Item 5a – Summary of Action Items:
  - Nate and Sunny to discuss the November face-to-face meeting need.
  - Sunny to send new voting member solicitation to MOPC after meeting.
  - Staff release SPP developed EHV Node-Breaker model with the next week on GlobalScape.
  - MDWG power flow focus group to develop the shunt device testing plan and work. Staff to bring planning concerns to the power flow focus group.
  - Members to provide additional feedback for DC armature resistance.

- Agenda Item 5b – Future Meetings:
Nate provided an overview of future meetings.
**- Agenda Item 5c – Adjourn Meeting:**
Nate Morris solicited a motion to adjourn the meeting.

Moses provided two reminders EDST testing is about to complete. Moses mentioned he would be resetting the passwords soon and communicate the change out to the group.

Derek Brown mentioned that this would be his last MDWG meeting as a voting member. Derek mentioned that Evergy will be nominating Jeremey Harris. Nate thanked Derek for the work in the group and driven the group. Nate thanked Derek for carrying the group when he was not. Eddie Watson he communicated his appreciation for Derek Brown's work and leadership.

**Motion:** Derek Brown made the motion to adjourn the meeting. Reené Miranda seconded it. The motion passed unanimously.

The meeting adjourned at 12:02PM (CDT).

Respectfully submitted,
Sunny Raheem
MDWG Secretary
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
June 6, 2019
Conference Call
• A G E N D A •
9:00 a.m. – 12:00 p.m. (CDT)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. May 20th, 2019 (Approval Item)
   g. Action Items Review
2. MDWG Face-to-Face Meeting Discussion ......................................... Nate Morris (15 mins)
3. MDWG Manual Language
   a. MOD Matrix (Approval Item*) ............................................ Moses Rotich (45 mins)
   b. Language Approval (Approval Item*) ................................. Michael Odom (45 mins)
4. Break ........................................................................................................ (10 mins)
5. Membership Nomination Announcements ........................................... Nate Morris (10 mins)
6. Node-Breaker Release Discussion ......................................................... Moses Rotich (10 mins)
7. 2019 MDWG Dynamics Model Build Update ................................. Sunny Raheem (10 mins)
8. MDWG Focus Group Updates
   a. Dynamics ................................................................. Marc Moor/Sunny Raheem (5 mins)
   b. Power Flow ............................................................. Jerad Ethridge/Moses Rotich (5 mins)
   c. Short Circuit ............................................................ Reené Miranda/Michael Odom (5 mins)

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9. Administrative Items ........................................................................................................ Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Next Conference Call: July 11th (9:00am – 12:00pm)
         2. Training
            a. Workshop: SPP Campus, Little Rock AR June 12th-13th
         3. Next Face-to-Face: Denver, CO October 22-23rd
      ii. Manual Task Force:
         1. 2nd, 3rd, and 4th Thursday of each month 9am-11am
      iii. Focus Groups Meetings:
         1. Power Flow: June 13th (1-2pm)
         2. Dynamics: June 13th (2-3pm)
         3. Short Circuit: June 13th (3-4pm)
   c. Adjourn

Note: The approval items denoted with “***” shall be jointly developed by PC, TP, and MDWG.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
May 20th: 3:00 P.M. – 5:00 P.M. (CDT)

· M I N U T E S ·

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 3:00 p.m and was proceeded by Sunny Raheem reading the anti-trust statement.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Present</th>
<th>Company</th>
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<tbody>
<tr>
<td>Nate Morris</td>
<td>YES</td>
<td></td>
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<td>Empire District Electric Company</td>
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<tr>
<td>Derek Brown</td>
<td>NO</td>
<td>Jeremy Harris</td>
<td>YES</td>
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<td>Andrew Berg</td>
<td>NO</td>
<td>John Weber</td>
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<td>Dustin Betz</td>
<td>YES</td>
<td>Jason Hofer (3:25 – 4pm)</td>
<td>YES</td>
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<td>John Boshears</td>
<td>NO</td>
<td>Kevin Foflygen</td>
<td>YES</td>
<td>City Utilities of Springfield</td>
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<td>Jerad Ethridge</td>
<td>YES</td>
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<td>Oklahoma Gas &amp; Electric</td>
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<td>Joe Fultz</td>
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<td>Holli Krizek</td>
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<td>Western Area Power Administration</td>
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<td>Reené Miranda</td>
<td>YES</td>
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<tr>
<td>Alex Mucha</td>
<td>YES</td>
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<td>Oklahoma Municipal Power Authority</td>
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<td>Scott Rainbolt</td>
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<td>Scott Schichtl</td>
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<td>Jason Shook</td>
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<td>GDS Associates</td>
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<td>Liam Stringham</td>
<td>YES</td>
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<td>Sunflower Electric Power Corporation</td>
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<tr>
<td>Sunny Raheem</td>
<td>YES</td>
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<td>Southwest Power Pool, Inc.</td>
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**Additional Guests present:**

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<th>Guests</th>
<th>Company</th>
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<tbody>
<tr>
<td>Cho Wang, Martin Green</td>
<td>American Electric Power</td>
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<tr>
<td>Josh Hesselbein</td>
<td>Arkansas Electric Cooperative Company</td>
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<td>Preston Blinsky, Jeremy Severson</td>
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<td>Adam Mummert</td>
<td>Burns and McDonnell</td>
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<td>Kevin Foflygen</td>
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<td>Tyler Baxter</td>
<td>Corn Belt Power Cooperative</td>
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<td>Jordan Lamb</td>
<td>East River Cooperative</td>
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<td>Jeff Crites</td>
<td>Empire District Electric Company</td>
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<td>Raman Somayajulu</td>
<td>Enel</td>
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<td>Cristina Ortiz, Jeremy Harris, Lafayette</td>
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<td>Baysinger</td>
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<td>Rebekah Kelman</td>
<td>Gridliance</td>
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<td>Charles Aleman</td>
<td>Golden Spread Electric Cooperative</td>
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<td>Michael Wegner</td>
<td>ITC Great Plains</td>
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<td>Ahsan Hasnine</td>
<td>LP&amp;L</td>
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<td>John Payne</td>
<td>Kansas Electric Power Cooperative</td>
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<td>John Weber</td>
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<td>Armin Sehic</td>
<td>Municipal Energy Agency of Nebraska</td>
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<td>Jason Hofer</td>
<td>Nebraska Public Power District</td>
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<td>Mark Mallard</td>
<td>Northwestern Energy</td>
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<td>John Mayhan</td>
<td>Omaha Public Power District</td>
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<td>Odom, Moses Rotich, Shahrrokh Akhlaghi,</td>
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<td>Vahram Stepanyan</td>
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– Agenda Item 1e(i) – Agenda Review (Approval Item):
Nate Morris asked the group if they had any modifications to the agenda.
Nate opened the floor to entertain a motion for approval of the updated meeting agenda.

Jason Shook made the motion to approve the agenda. The group did not voice concern during the discussion of the motion. Scott Schichtl seconded the motion. The motion passed unanimously.

Background Material for Motion: MAY20_MM_Attach1 - 1e. MDWG Meeting Agenda 20190520.docx

– Agenda Item 1f(i) – May 2nd, 2019 Meeting Minutes Review (Approval Item):
Nate then proceeded to ask the group whether they had any modifications to the 5/2/2019 meeting minutes. Sunny presented the redlines staff received by SPS for additional details pertaining to the model selection discussion from the 5/2/2019 MDWG conference call. There was no additional discussion or feedback to the minutes from the group.

Nate opened the floor to entertain a motion for approval.

Motion: Jason Shook made the motion to approve the May 2nd meeting minutes as presented on the screen. The group did not voice concern during the discussion of the motion. Scott Schichtl seconded the motion. The motion passed unanimously.

Background Material for Motion: MAY20_MM_Attach2 - 1f. MDWG Minutes May 2, 2019.pdf
– **Agenda Item 1g – Action Items Review:**
Sunny presented an overview of the action items and briefly discussed recently completed items and those to be covered during the meeting. Moses Rotich provided the June 28th tentative release for action item #41. The group asked for additional details around action item #41 and if the dynamics could be built on PSSE version 34.6 instead of version 34.5.1. Staff mentioned that a subversion version change of PSSE v34 is something that can be discussed and incorporated during the development of the 2020 dynamic model build schedule. Michael Odom gave an update on the short circuit data request to MISO and mentioned that staff is sending out the SPP external short circuit data request within the next week. There was no additional discussion or feedback to the minutes action items from the group.

**Agenda Item 2 – MDWG Focus Group Updates**
Nate Morris requested the MDWG focus group leaders and/or staff support to provide an update from their respective groups.

– **Agenda Item 2a – Dynamics:**
Marc Moor mentioned the last MDWG Dynamic Focus Group on May 8th. Marc mentioned the group is still going through the MDWG manual. Marc mentioned the group is working on dynamic model guidelines and member issues and topics. Marc mentioned in the next few meetings the group will be discussing the dynamics DocuCheck and damping criteria. Sunny mentioned he would like to thank Marc for his leadership and willingness to share information in this focus group.

– **Agenda Item 2b – Power Flow:**
Jerad Ethridge mentioned the Power Flow Focus Group discussed the model selection. Jerad mentioned the focus group conversation was very similar to the last MDWG conference call. Jerad mentioned that he placed python scripts on the planning drive for additional model building effort. Moses Rotich mentioned the Power Flow Focus Group would like to talk to MDWG about the release of the node-breaker modeling at a future meeting. Jerad mentioned the Power Flow Focus Group would like to discuss the MOD Matrix revision at the next MDWG meeting. Nate Morris and the group thanks Jerad and others for sharing information in this forum.

– **Agenda Item 2c – Short Circuit:**
Reené Miranda provided a update on the recent Short Circuit Focus Group meetings and discussion including mutual impedance and external data request. Reené thanked Andrew Berg for stepping in to lead the short circuit meeting. Reené mentioned the MISO data request should be going out this month.

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**Agenda Item 3 – MOD-032 GIA Milestone Language Review:**
- **Agenda Item 3a – Designating MOD-032-1 Data Submittal (Approval Item):**

Sunny Raheem presented the Designating MOD-032-1 Data Submittal Letter. Sunny mentioned staff would like to request for this to be approved as an appendix to the MDWG manual. Sunny mentioned that staff has kept record of which data submitter is submitting data on the behalf of a different data owner entity in a spreadsheet in the past but this would provide a more consistent form for that communication. The group asked if their Legal departments could alter the agreement. Sunny mentioned that could add additional complexities for SPP to review and accept since it would have to be reviewed by SPP Legal. Jonathan Hayes provided clarification that this letter agreement is not intended to be an agreement between the data submitter and owner’s actual responsibility, but it’s a letter notice to SPP as the Planning Coordinator on who will be sending the data to SPP. The group review the language in the letter and provide no further edits at this time.

Nate opened the floor to entertain a motion for approval.

**Motion:** Reené Miranda made the motion to approve the Letter of Notice to Designate MOD-032-1 Data Submittal Assignment and append it to the MDWG Manual as an appendix. The group did not voice concern during the discussion of the motion. Jerad Ethridge seconded the motion. The motion passed unanimously.

**Background Material for Motion:** MAY20_MM_Attach3 - 3a. Designating MOD-032-1 Data Submittal Assignment Letter_04262019.docx

**Action Item:** Staff to communicate the Letter of Notice with Generator Owners, Data Owners, and Data Submitters.
**Agenda Item 4 – 2020 MDWG Powerflow/Short Circuit Model Build:**
Agenda item tabled for future meeting.

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**Agenda Item 4a – PSS®E v34.5.1, MOD v10, and MDWG Manual Version:**
Moses Rotich provided a quick review of the current planned PSSE and MOD version for the 2020 MDWG power flow and short circuit builds. Jason Hofer announced his departure. The group discussed the possibility of changing version in the middle of the build schedule or keeping PSSE v34.5.1 for full build. Reéné commented that SPS had to get approval from their IT department to certify their software so it could take up a while to get approval for PSSE software changes. Jeremy Harris mentioned the company merge could slow down IT approval for PSSE software changes. Jason Shook suggested that we stick to v34.5.1. Jerad Ethridge supported this idea and had concerns with Siemens releasing v34.6 before the model build starts. Mark Mallard commented that the powerflow changes between PSSE v34.5.1 were minimal based on what was presented to him at the Siemens UGM. John Mayhan asked if PSSE v34.6 could be used for dynamic if v34.5.1 is used for power flow. Sunny commented that with minimum powerflow changes he would be ok with v34.6 for the 2020 dynamics model build. Nate commented he would prefer that powerflow and dynamics stick to the same PSSE point revision given the consideration for network licenses at different companies. The group agreed with this approach.

Moses talked the about the MOD version and the availability of the MTE environment for data submitters. Moses noted that the data in the current v8 production environment is being converted to v10. Once all the work is completed with the conversion, an email will be sent to all data submitters with instructions on accessing both the MTE and PROD environments.

Michael Odom mentioned the plan is to have the approved MDWG manual version posted before the model build starts.
– Agenda Item 4b – Schedule (Approval Item*):
Moses Rotich presented the schedule and commented that this was discussed in the previous MDWG meeting. Nate Morris asked about the line item on the conversion of models to v33. Moses explained that it is to help other SPP internal groups for their automation transition. Jeremy Harris asked if the conversion is also done when moving to a future version of PSSE. Moses answer that is something that can be considered in the future. The group review the schedule, requirements, and meeting times during the model build.

Nate opened the floor to entertain a motion for approval.

Motion: Jason Shook made the motion to approve the 2020 MDWG power flow and short circuit schedule as presented in the background material. The group did not voice concern during the discussion of the motion. Alex Mucha seconded the motion. The motion passed unanimously.

Background Material for Motion: MAY20_MM_Attach4 - 4b. 2020 MDWG PowerFlow Short Circuit Schedule.xlsx

– Agenda Item 4c – Model Selections (Approval Item*):
Michael Odom presented the ITP BR, Market Powerflow, and MDWG model differences. The group discussed the differences presented. Some in the group questioned the number of models due to the Year 1 not being aligned. Michael mentioned that staff has worked over the last year to reduce models through other achievable efforts. Staff mentioned that an option might be to bring the model reduction effort to TWG and see if a task force can be developed to address it from holistic view.

Nate opened the floor to entertain a motion for approval.

Motion: Jason Shook made the motion to approve the 2020 MDWG / 2021 ITP circuit schedule as presented in the background material. The group did not voice concern during the discussion of the motion. Jeremy Harris seconded the motion. The motion passed with one abstention.

Reené Miranda mentioned he abstained the MDWG Model Selection vote is due number of models that are being built and the fact that some models provide little value. One example is the building of future models, specifically the MDWG year 10 and year 11. The one year difference in models does not provide a significant difference between the two models. Additionally, it does not appear that the different planning processes at SPP are willing to compromise and adjust the models they each used to reduce the entire model set. All these models are providing additional burden to the membership, when it comes to checking models and providing feedback to SPP at each pass.

Background Material for Motion: MAY20_MM_Attach5 - 4b&4c. 2020 MDWG & 2021 ITP Model Selection.pptx
Agenda Item 5 – Administrative Items:
- Agenda Item 5a – Summary of Action Items:
  - Staff to communicate the Letter of Notice with Generator Owners, Data Owners, and Data Submitters.

- Agenda Item 5b – Future Meetings:
  Nate provided an overview of future meetings.

- Agenda Item 5c – Adjourn Meeting:
  Nate Morris solicited a motion to adjourn the meeting.

Motion: Jerad Ethridge made the motion to adjourn the meeting. Alex Mucha seconded it. The motion passed unanimously.

The meeting adjourned at 5:02PM (CDT).

Respectfully submitted,
Sunny Raheem
MDWG Secretary
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
May 20, 2019
Conference Call
• A G E N D A •
3:00 p.m. – 5:00 p.m. (CDT)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. May 2th, 2019 (Approval Item)
   g. Action Items Review

2. MDWG Focus Group Updates
   a. Dynamics ................................................................. Marc Moor/Sunny Raheem (10 mins)
   b. Power Flow ............................................................... Jerad Ethridge/Moses Rotich (10 mins)
   c. Short Circuit ............................................................. Reené Miranda/Michael Odom (10 mins)

3. MOD-032 GIA Milestone Language Review
   a. Designating MOD-032-1 Data Submittal (Approval Item*) ............ Sunny Raheem (10 mins)

4. 2020 MDWG Powerflow/Short Circuit Model Build
   a. PSS®E v34.5.1, MOD v10, and MDWG Manual Version ................. Moses Rotich (5 mins)
   b. Schedule (Approval Item*) .................................................. Moses Rotich (25 mins)
   c. Model Selections (Approval Item*) ......................................... Michael Odom (30 mins)

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5. Administrative Items ........................................................................................................... Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Next Conference Call: June 6th (9:00am – 12:00pm)
         2. Training
            a. Workshop: SPP Campus, Little Rock AR June 12th-13th
         3. Next Face-to-Face: Denver, CO October 22-23rd
      ii. Manual Task Force:
         1. 2nd, 3rd, and 4th Thursday of each month 9am-11am
      iii. Focus Groups Meetings:
         1. Power Flow: May 20th (9:30 – 11:30am)
         2. Dynamics: June 12th (9:30 – 11:30am)
         3. Short Circuit: June 25th (9:00 – 11:00am)
   c. Adjourn

Note: The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG.

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Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:01 a.m and was proceeded by Sunny Raheem reading the anti-trust statement.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

**MDWG Members present:**

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<thead>
<tr>
<th>MDWG Member</th>
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Additional Guests present:

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<td>Alan Burbach</td>
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<td>Shawnnee Claiborne-Pinto</td>
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<td>Odom, Moses Rotich, Shahrokh Akhlaghi,</td>
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-Agenda Item 1e(i) – Agenda Review (Approval Item):
Nate Morris asked the group if they had any modifications to the agenda. Reené Miranda mentioned he would like to request to amend the agenda to remove the approval tag for the 2020 MDWG schedule and model selection discussion. Nate requested clarification for the amendment. Reené mentioned he would like to discuss the model selection before it comes up for approval. Reené mentioned this is the first time the MDWG has seen the model selection material.
Reené Miranda made the motion to modify the agenda to remove 2020 MDWG Schedule and Model Selection as the approval items and maintain those items as discussion items for the agenda. The group discussed if the schedule should be amended to remove approval since it was presented at the MDWG power flow focus group. After discussion, Nate asked Reené if he would like to continue with his motion or amend it. Reené requested to continue with his original motion. Holli Krizek seconded the motion. The motion passed with one abstention from Jeremy Harris (Evergy).

Evergy abstained due to not having any issues with the model selection or schedule as they were presented in the background materials, and also did not want to make a determination to not approve them prior to having the discussions.
Nate opened the floor to entertain a motion for approval of the updated meeting agenda.

Jason Shook made the motion to approve the amended agenda. The group did not voice concern during the discussion of the motion Scott Schichtl seconded the motion. The motion passed unanimously.

**Background Material for Motion:** MAY02_MM_Attach1 - 1e. MDWG Meeting Agenda 20190502_redline.docx

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**Agenda Item 1f(i) – April 4th, 2019 Meeting Minutes Review (Approval Item):**
Nate then proceeded to ask the group whether they had any modifications to the 4/4/2019 meeting minutes. Sunny mentioned that staff would like to propose redline clarification in the meeting minutes for the MDWG Charter Standardization effort. There was no additional discussion or feedback to the minutes from the group.

**Motion:** Dustin Betz made the motion to approve the April 4th meeting minutes as amended. The group did not voice concern during the discussion of the motion. Alex Mucha seconded the motion. The motion passed unanimously.

**Background Material for Motion:** MAY02_MM_Attach2 - 1f. MDWG Minutes February 28, 2019_redlined.pdf

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**Agenda Item 1g – Action Items Review:**
Sunny presented an overview of the action items and briefly discussed recently completed items and those to be covered during the meeting. Sunny briefly discussed some of the GIA milestone and agreement items that will be covered during the meeting. Michael Odom gave an update on the short circuit data request to MISO and mentioned that staff has a meeting planned with MISO next week pertaining to the short circuit data request. There was no additional discussion or feedback to the minutes from the group.

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**Agenda Item 1h – Draft 2020 MDWG Workshop Agenda:**
Nate explained the preview purpose of the Draft 2020 MDWG Workshop Agenda material. Sunny provided an outline of the agenda to the group. Sunny mentioned the group could direct other agenda topics or feedback to staff.
Agenda Item 2 – 2020 MDWG Powerflow/Short Circuit Model Build:
- Agenda Item 2a – PSSE v34.6, MOD v10, MDWG Manual Version:
Moses mentioned the PSSE v34.5 has issues with the parallel ACCC functions. Moses mentioned Siemens PTI fixed several bugs in v34.6. Moses provided the status of the MOD v10 testing. Moses outlined some of the enhancements and bug fixes that will be beneficial to the group. Michael provided an overview of the thought process behind the MDWG manual approval. Michael mentioned the MDWG manual version being locked down for compliance of the upcoming model build closer to the model build kick-off. Michael said that changes can still be made to the manual after that approval but they will not apply to the upcoming model build unless the group decides otherwise. Moses asked if the group had any questions or comments.

The group discussed the late May release date for PSSE v34.6 and its affects to the model build schedule. Moses mentioned he would follow up with Siemens on the actual release date for v34.6. The group talked about the file format differences between PSSE v34.5 and v34.6. Moses mentioned that he was not aware of any significant differences in file formats. The group discussed the middle of May deadline for MOD v10 testers to provide bugs in efforts of getting corrections from Siemens PTI by the model build timeframe.

Action Item: Staff to check with Siemens PTI on the actual release date for PSSE 34.6.
-- Agenda Item 2b – Schedule:
Moses presented the staff proposed schedule from start to finish. Moses described the identified efficiencies built into the schedule by incorporating economic model build milestones, short circuit and MOD-033 inputs. Moses talked about the dependencies of the economic models to the powerflow models and also briefly described the current gap between GI and modeling and how staff is proposing to bridge that gap through the MDWG schedule and GIA milestones.

Moses stressed the two data cutoff dates for certain data pieces such as load, generator additions and retirements, etc. Moses mentioned the proposed December 13th, 2019 deadline would be for final submission for Transmission Service Inputs (AG1) Data, review Pass 2 models/data submission through MOD, update load and generation reports/reconcile transaction discrepancies. Moses mentioned Pass 2 would be the last change to submit generator additions, generator retirements, load additional or removals, and set area interchange. Moses mentioned the February 7th, 2020 deadline will be the final generation dispatch, DocuCheck corrections, and topology data updates through MOD and EDST.

The group discussed how the ITP schedule relates to the MDWG schedule. Staff mentioned the MDWG and ITP schedule dates are very similar from the start of the model builds in July and up to the approval in March. The ITP schedule then continues until the November while the MDWG models are approved as final at the March meeting.

The group discussed face-to-face meeting options for October, November, and January timeframes. Some members preferred not to meet for MDWG business in January given the current model build milestones occurring at the same time. Others mentioned the benefits and amount of good discussion and action items because of the previous January meeting. Jeremy Harris commented that having a November timeframe meeting is ideal for future builds since data is locked down around December so this would provide more benefit. Andy Berg commented that in the previous build MRES and BEPC discovered some issues along the seams after merging with MMWG models around January this year so having the meeting January could provide a forum to discuss such issues. Moses also supported Andy by commenting that data submitters wishing to submit data already locked down could use this forum to discuss their updates before they are finalized.

**Action Item:** Staff to review the October/November timeframe for the face-face meeting.
- Agenda Item 2c – Model Selection:
Michael Odom provided an overview of the model selection. Michael brought the group up to speed on the latest information on TPL concerns for Year 1. Michael mentioned that SPP Modeling Staff was close to aligning the Year 1 definition however there is concern internal to SPP for shifting the TPL Year 1 definition. Jonathan Hayes clarified the concern is around the lead-time for Correction Action Plans (CAPs). Michael mentioned the timing of the model finalization in November is a major contributor to the concern. The group discussed options for reconciling the Year 1 difference. The group voiced concerns over the current model selection including the number of models and the need for year 11 models. Sunny Raheem mentioned that there have been other total number of model reduction efforts outside the scope of aligning Year 1, which eliminated ten models in MDWG dynamics and one model at MMWG during the last year. Jason Terhune provided an overview of the SPP process after MDWG power flow models are finalized in March to November when the TPL assessment starts. Jason mentioned the final models are delivered to his group in November and his group will conduct the assessment over the next 12 months. Jason mentioned posting in November with Year 1 aligned would provide results for a seasonal model that has already passed. The group discussed the possibility of a joint effort between MDWG and TWG to 1) change the model build schedule or 2) additional tariff or SPP business practice changes to align Year 1.

Action Item: Staff to share TPL model swim lane diagram with MDWG

In efforts of continue with the meeting agenda, Nate tabled the rest of the discussion and requested another conference call be scheduled for May 20th to continue the 2020 MDWG model selection and schedule.

Action Item: Staff to schedule a MDWG WebEx meeting or May 20th, 2019.

Agenda Item 3 – Break:
The group took a ten-minute break.

Agenda Item 4 – Node-Breaker Release Discussion:
Agenda item tabled for future meeting.

Agenda Item 5 – MOD-032 GIA Milestone Language Review:

- Agenda Item 5a – MOD-032 GIA Milestone Language Review:
Sunny presented the MOD-032 GIA milestone language edits received to date. Sunny mentioned the goal of this effort is to get the GIA milestone language reviewed and included in upcoming GIA negotiations to close communication gaps between GIAs and MOD-032. Sunny mentioned that OPPD provide some redline to the GIA milestones. OPPD and Evergy provided suggested redlines during the discussion for clarification and consistence purposes. The group did not voice any additional concerns after the redlines were included in the working document.

Background Material: MAY02_MM_Attach3 - 4a. GIA Milestone Language_redline.docx

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- **Agenda Item 5b – Designating MOD-032-1 Data Submittal (Approval Item*)**
  Agenda item tabled for future meeting.

**Agenda Item 6 – MDWG Manual Language:**
- **Agenda Item 6a – MOD Matrix (Approval Item*):**
  Agenda item tabled for future meeting.

- **Agenda Item 6b – Language Approval (Approval Item*):**
  Agenda item tabled for future meeting.

- **Agenda Item 7 – MDWG Focus Group Updates:**
  - **Agenda Item 7a – Dynamics:**
    Agenda item tabled for future meeting.

- **Agenda Item 7b – Power Flow:**
  Agenda item tabled for future meeting.

- **Agenda Item 7c – Short Circuit:**
  Agenda item tabled for future meeting.

- **Agenda Item 9 – Administrative Items:**
  - **Agenda Item 5a – Summary of Action Items:**
    - Staff to check with Siemens PTI on the actual release date for PSSE 34.6.
    - Staff to review the October/November timeframe for the face-face meeting.
    - Staff to share TPL model swim lane diagram with MDWG.
    - Staff to schedule a MDWG WebEx meeting or May 20th, 2019.

- **Agenda Item 5b – Future Meetings:**
  Nate mentioned May 20th will be the next meeting. The rest of the future meeting discussion was tabled due to the meeting time constraint.

- **Agenda Item 5c – Adjourn Meeting:**
  Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

**Motion:** Andy Berg made the motion to adjourn the meeting. Jeremy Harris seconded it. The motion passed unanimously.

The meeting adjourned at 12:13PM (CDT).

Respectfully submitted,
Sunny Raheem
MDWG Secretary

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Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
May 2, 2019
Conference Call
• A G E N D A •
9:00 a.m. – 12:00 p.m. (CDT)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. April 4th, 2019 (Approval Item)
   g. Action Items Review
   h. Draft 2020 MDWG Workshop Agenda

2. 2020 MDWG Powerflow/Short Circuit Model Build
   a. PSS®E v34.6.0, MOD v10, and MDWG Manual Version ................. Moses Rotich (10 mins)
   b. Schedule (Approval Item*) ................................................................. Moses Rotich (20 mins)
   c. Model Selections (Approval Item*) ................................................... Michael Odom (30 mins)

3. Break ........................................................................................................................................ (10 mins)

4. Node-Breaker Release Discussion ......................................................... Moses Rotich (10 mins)

5. MOD-032 GIA Milestone Language Review
   a. GIA Milestone Language ................................................................. Sunny Raheem (5 mins)
   b. Designating MOD-032-1 Data Submittal (Approval Item*) ............ Sunny Raheem (10 mins)

6. MDWG Manual Language
   a. MOD Matrix (Approval Item*) ........................................................... Moses Rotich (5 mins)
   b. Language Approval (Approval Item*) ............................................... Michael Odom (30 mins)

7. MDWG Focus Group Updates
   a. Dynamics ...........................................................Marc Moor/Sunny Raheem (10 mins)
   b. Power Flow ..............................................................Jerad Ethridge/Moses Rotich (10 mins)
   c. Short Circuit.....................................................Reené Miranda/Michael Odom (10 mins)

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8. Administrative Items ........................................................................................................... Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Next Conference Call: June 6\textsuperscript{th} (9:00am – 12:00pm)
         2. Training
            a. Workshop: SPP Campus, Little Rock AR June 12\textsuperscript{th}-13\textsuperscript{th}
         3. Next Face-to-Face: Denver, CO October 22-23\textsuperscript{rd}
      ii. Manual Task Force:
         1. 2nd, 3\textsuperscript{rd}, and 4\textsuperscript{th} Thursday of each month 9am-11am
      iii. Focus Groups Meetings:
         1. Power Flow: May 6\textsuperscript{th} (9:30 – 11:30am)
         2. Dynamics: May 8\textsuperscript{th} (9:30 – 11:30am)
         3. Short Circuit: May 28\textsuperscript{th} (9:00 – 11:00am)
   c. Adjourn

Note: The approval items denoted with “***” shall be jointly developed by PC, TP, and MDWG.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
April 4th: 9:00 A.M. – 12:00 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:02 a.m and was proceeded by Moses reading the anti-trust statement.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

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<td>Moses Rotich</td>
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<td>Kevin Samuel</td>
<td>NextEra Energy</td>
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**Agenda Item 1e(i) – Agenda Review (Approval Item):**

Nate asked whether the group had any modifications to the agenda. Moses suggested a modification to the node-breaker educational training date but he was later notified that the date is reflected correctly.

**Motion:** Dustin Betz made the motion to approve the agenda as presented. Reené Miranda seconded the motion. The motion passed unanimously.

**Background Material for Motion:** APR04_MM_Attach1 - 1e. MDWG Meeting Agenda 20190404.docx

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**Agenda Item 1f(i) – February 28th, 2019 Meeting Minutes Review (Approval Item):**

Nate then proceeded to ask the group whether they had any modifications to the 2/28/2019 meeting minutes. There was no discussion or feedback to the minutes.

**Motion:** Andy Berg made the motion to approve the February 28th, 2019 meeting minutes as presented. Jason Shook seconded it. The motion passed.

- Alex Mucha abstained because he wasn’t in attendance at the February 28th, meeting.

**Background Material for Motion:** APR04_MM_Attach2 - 1f. MDWG Minutes February 28, 2019.pdf

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**Agenda Item 1g – Action Items Review:**

**Antitrust:** SPP strictly prohibits use or participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
Moses presented an overview of the action items and briefly discussed recently completed items and those to be covered during the meeting.

- **Agenda Item 2 – MDWG Charter Revision Update:**
  Moses briefly gave an update on the MDWG charter revision. He commented that it had been approved by the Corporate Governance Committee (CGC) and that the next step is to take it to the SPP Board of Directors (BOD) for approval. He also said that once approved, SPP staff & MDWG Chairman might modify some wording to make sure that it doesn’t conflict with the SPP bylaws in accordance with the .SPP Scope standardization effort. Nate then reminded the group that once approved, the group will solicit new members since the charter will allow an increase in MDWG membership.

- **Agenda Item 3 – EDST Enhancement Updates**
  Moses presented a high level overview of the EDST enhancements that are being implemented by SPP IT. He also discussed the timeline of when members will be expected to test the new features, uncover any bugs and report them to SPP so that they can be fixed before the model build begins. He stated that prior to testing, SPP will most likely schedule a 1-2 hr conference call to perform a demo of the enhancements and take any questions prior to testing. Furthermore, he said that more information will be provided closer to testing. He then requested that Data Submitters send himself or the modeling team an email if interested in testing.

  During discussion, a question was posed on the number of Data Submitters required for testing. Moses and Eddie answered that there is no minimum number of testers and that having more people test provides additional benefit in terms of identifying any bugs or enhancements.

- **Agenda Item 4 – Model on Demand Version 10 Update:**
  Moses briefly gave an update on Model On Demand (MOD) v10. He told the group that had given the Change Working Group (CWG) an update on MOD v10 testing, the prior week. He said that the CWG is interested in learning more about some of the member facing/impacting tools that are used by SPP engineering. Moses then proceeded to give a background on MOD, some of the v10 enhancements and the testing timeline. After the presentation, he requested that Data Submitters interested in testing, send himself or the SPP modeling team an email. Once a list of testers is compiled, a small kickoff meeting will be scheduled to walk through MOD v10 and discuss any expectations.

- **Agenda Item 5 – MOD-032 GIA Milestone Language Review:**
  Moses commenced discussion by noting mentioning that the intent of this milestone is to close the gap in terms of requesting data from Generator Owners (GO). He said that that the MOD-032 milestones would be included in the Generation Interconnection Agreement (GIA) in order for preliminary and as built data to be provided within a certain period after the GIA effective date. During the presentation, many questions were posed with regard to the number of days allotted for Generator Owners and Transmission Owners to provide modeling information, and whether some of the modeling data (powerflow and short circuit) can be provided 120 days prior to commercial operation of the Generators. Furthermore, it was also suggested that powerflow and short circuit data should be known well in advance of the commercial operation date whereas dynamic data could be provided using generic models until testing is done and a standard model can be submitted. With regard to the time allotted for GOs and TOs to submit modeling information, many in the group seemed to be in favor of allowing 120 calendar days.
for data to be submitted to SPP. Kevin Samuel (NexEra Energy) opined that as a GO, they would be in favor of the 120 calendar days rather than 60 days, since the data can take some time to gather. After some good deliberation amongst the group, Chris Colson then commented that he would also like to see language added to the GIA that explicitly require a Generator Owner to identify their Transmission Planner (TP).

After much debate on the MOD-032 GIA milestone language, Moses proceeded to talk about the Designating MOD-032-1 Data Submittal Assignment.docx draft document that GOs or any other entities can sign to show who will submit modeling data to SPP on their behalf. Jerad then suggested that some language be added to this draft document to allow entities opt out of the agreement upon notice.

**Action Item:** Staff to check with SPP legal to see if they have some language that can be added to the draft Designating MOD-032-1 Data Submittal Assignment.docx document to allow entities to opt out of the agreement.

 Whereas some in the group expressed the need to help GOs submit modeling data in order to more accurately reflect the system in the models, others reiterated the need for GOs to learn and become fully engaged in the SPP modeling process by submitting their own data in the required format. Eddie then requested that the group continue to inform SPP of any generators changing owners and those going to commercial operation in the near-term but not reflected in the latest planning models. Many in the group agreed that this is something that still needs to be done in order to ensure that the resources are accurately reflected in the models. Reene then asked if GOs with GIAs on suspension would still be required to provide modeling data per the draft MOD-032 milestone. He was of the opinion that these GOs still need to provide the data. Some of the other questions posed are: 1) how should some large units not registered at NERC be handled? 2) Are resources registered in the SPP market required to be modeled? 3) Is it possible to share the resources registered in the SPP market with Transmission Owners (TOs) and Transmission Planners (TPs)?

Moses answered that there is currently language in the MDWG model development procedure manual requiring that all resources registered in the SPP market be included in the models. Michael then commented that he would have to check with SPP legal to see if it possible to share those resources registered in the market, with TOs and TPs. Just as the discussion was coming to a conclusion, Chris asked whether the draft agreement would be applied retroactively or only apply to new GIAs, and if not signing the agreement would withhold information from the models. Moses answered that it could be used retroactively and that the GO would still be required to provide modeling data regardless of whether the agreement is signed.

**Action Item:** Data Submitters to review agreement and provide an answer within a month

- **Agenda Item 7 – MDWG Focus Group Updates:**

Marc presented an update on the dynamics focus group activities. He expressed that they had discussed the following topics: MOD v10 testing for dynamics and the need to have volunteers to test out the dynamics functionality, the dynamics unacceptable model list, turbine modeling for conventional units, debrief of NERC generator modeling and some Siemens AHA ideas. He noted that next week, they would discuss some enhancements that SPP is working on with Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
regards to dynamics, and renewable modeling, and some manual language on generator modeling.

Jerad gave an update on the powerflow focus group (pf fg) activities. He mentioned that one of the items discussed recently was the MOD matrix with a recommendation that would be discussed later at the MDWG today. Another item recently discussed was manual language on shunt modeling and their impacts to some studies such as TPL, AQ, and GI. He noted that the pf fg didn't come to a conclusion on the shunt modeling and also mentioned some other items for discussion at upcoming meetings.

Reené presented on the short circuit focus group activities. He talked about the short circuit modeling data request template and mentioned that MISO doesn't build a short circuit model. The template is still being reviewed for finalization but will be sent once completed, to get short circuit data from external entities along the SPP seams. He also talked about some manual language for the short circuit section and said that Marc volunteered to put together some slides on Mutual data modeling in PSSE.

Nate then asked if anyone had comments or questions for the Focus Group leaders. There were no questions; however, Michael mentioned that items need to be prioritized in the FGs for implementation before the next model build. Jerad also mentioned that another topic for future discussion is which manual version should be used for compliance; the manual before or after the model build. Nate answered that maybe this can even be added to the overall model build schedule. Moses then reminded the group to send requests if they would like to be added to the FG email distribution lists.

- Agenda Item 8 – MDWG Manual Language (Approval Item):
Michael presented on some of the manual changes. He noted that there were some changes still being worked on but wholesale changes will be brought to the group at a later date.

For the proposed language on non-conforming loads, Andy commented that it seemed sufficient. Nate asked if there were any other comments or additional discussion on this language. There were no dissenting voices when it came to this language.

For the proposed language on shunt modeling, there were varying opinions. Andy commented that moving forward with this concept of shunt modeling will potentially lead to a lot more violations showing up in the ITP and TPL studies. Chris expressed a different view; he liked the new proposed language as it helps end users know how the shunts typically operate and could help in the SPP Generation Interconnection (GI) process where you have new resources using other people’s ancillary services and thus weakening the short circuit strength of certain parts of the system. Jerad then noted that a third alternative would be for SPP to collect all the shunt typical operation data and create PSSE .idv files for end users to implement in during their own internal TPL assessments. Due to a lot of deliberation over this item, Michael suggested that this language be sent back to the powerflow focus group for further discussion before bringing back to the MDWG for approval. Nate agreed with this recommendation.
Seeing no further discussion, Nate entertained a motion from the group to approve the proposed language on non-conforming loads.

**Motion:** Jason Shook made the motion to approve the non-conforming language as presented. Jerad seconded it. The motion passed.

**Background Material for Motion:** APR04_MM_Attach3 - 8. SPP Model Development Procedure Manual 2019 v2.3_Working_Pending.docx

The MOD matrix was tabled for the next MDWG meeting; however, Moses commented that the sooner the MOD matric is approved, the sooner updates can be made in MOD in preparation for the upcoming model build.

**Agenda Item 9 – Administrative Items:**
- **Agenda Item 5a – Summary of Action Items:**
  Moses reviewed the action items that were captured during discussion:
  - Staff to check with SPP legal to see if they have some language that can be added to the draft Designating MOD-032-1 Data Submittal Assignment.docx document to allow entities to opt out of the agreement.
  - Data Submitters to review agreement and provide an answer within a month

- **Agenda Item 5b – Future Meetings:**
  Eddie informed the group that Theva would be departing SPP and any short circuit requests or questions should be submitted to the SPP engineering modeling email list.
  Moses reminded the group of the node breaker training on April 11th and some changes to the GlobalScape folder structure in the next few days.

- **Agenda Item 5c – Adjourn Meeting:**
  Seeing no further discussion due to time constraints, Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

**Motion:** Andy Berg made the motion to adjourn the meeting. Jason Shook seconded it. The motion passed unanimously.

The meeting adjourned at 12:04PM (CDT).

Respectfully submitted,
Moses Rotich
SPP Staff
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
April 4, 2019
Conference Call
• A G E N D A •
9:00 a.m. – 12:00 p.m. (CDT)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. February 28th, 2019 (Approval Item)
   g. Action Items Review
2. MDWG Charter Revision Update ............................................... Moses Rotich (5 mins)
3. EDST Enhancement Updates ..................................................... Moses Rotich (20 mins)
4. Model on Demand Version 10 Update ...................................... Moses Rotich (20 mins)
5. MOD-032 GIA Milestone Language Review ............................. All (20 mins)
6. Break ......................................................................................... (10 mins)
7. MDWG Focus Group Updates
   a. Dynamics .................................................................Marc Moor/Sunny Raheem (15 mins)
   b. Power Flow ...............................................................Jerad Ethridge/Moses Rotich (15 mins)
   c. Short Circuit ..............................................................Reené Miranda/Michael Odom (15 mins)
8. MDWG Manual Language (Approval Item*) ...................................Michael Odom (40 mins)
   a. MOD Matrix ..................................................................Moses Rotich
9. Administrative Items .................................................................... Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Next Conference Call: May 2nd (9:00 – 12:00pm)
         2. Training
            a. PSSE 34 Node Breaker Conference Call, April 11th
            b. Workshop: SPP Campus, Little Rock AR June 12th-13th
         3. Next Face-to-Face: Denver, CO October 22-23rd
      ii. Manual Task Force:
          1. 2nd, 3rd, and 4th Thursday of each month 9am-11am

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iii. Focus Groups Meetings:
   1. Power Flow: April 8th (9:30 – 11:30am)
   2. Dynamics: April 10th (9:30 – 11:30am)
   3. Short Circuit: April 23th (9:00 – 11:00am)

c. Adjourn

Note: The approval items denoted with “***” shall be jointly developed by PC, TP, and MDWG.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
February 28th: 9:00 A.M. – 11:00 A.M. (CST)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:02 a.m. on February 28th. The SPP Antitrust statement was read to the group at the start of the meeting on February 28th.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

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<th>Proxy</th>
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<td>YES</td>
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<td>John Weber (After 10am)</td>
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– **Agenda Item 1e(i) – Agenda Review(Approval Item):**
Nate asked the group if they had any modifications to the agenda or issues with the posted material. Sunny Raheem mentioned staff recommends redlining the meeting date to March 18th for the upcoming Node-Breaker education session since there is an overlap conflict with TWG on March 14. The updates are for an education session and a correction to the short circuit focus group meeting.

Nate opened the floor to entertain a motion.

**Motion:** Andy Berg motioned to approve the agenda as edited during the meeting Jerad Ethridge seconded the motion. The motion passed unanimously.

**Background Material for Motion:** FEB28_MM_Attach1 - 1e. MDWG Meeting Agenda 20190228_redline.docx

– **Agenda Item 1f(i) – February 15th, 2019 Meeting Minutes Review(Approval Item):**
Nate Morris presented the February 15th meeting minutes. The group discussed the meeting minutes. The group proposed redline corrections to the to the agenda item #1f minutes and agenda #3’s title.

Nate opened the floor to entertain a motion.

**Motion:** Jason Shook motioned to approve as amended February 15th 2019 meeting minutes. Scott Schichtl seconded the motion. The motion passed with no opposed and one abstained. Reené Miranda stated that he abstained since he was not present at the last meeting.

**Background Material for Motion:** FEB28_MM_Attach2 - 1fi. MDWG Minutes February 15, 2019_redline.pdf

– **Agenda Item 1g – Action Items Review:**
Sunny Raheem presented an overview of the action items that are in-progress and are recently completed. Sunny presented the status for in-progress and recently completed items since the last MDWG meeting the week before. The group expressed interest in reviewing the progress and material for action item #35, MOD-032 language inclusion in the SPP GIA.

**Action Item: Staff to bring draft GIA milestone language back to the April MDWG Meeting for discussion.**
- Agenda Item 2 – 2019 MDWG Short Circuit Model Series Approval (Approval Item):
Nate Morris introduced the group to the 2019 MDWG short circuit model series agenda item. Nate asked Theva Coleman to give a summary of the recent activities for this project. Theva provided the group the GlobalScape location of the proposed final models, important notes, and supporting file names with descriptions. Theva mentioned she received a few model corrections for the merge with MidAmerican Electric Company (MEC). Staff recommended approving the models as final with post processing idevs. The group discussed the need for re-running the fault analysis testing on the final cases after post-processing idevs are applied.

Nate opened the floor to entertain a motion.

Motion: Reené Miranda motioned to approve 2019 MDWG power flow model series as final with applied posting processing idevs and fault testing completed. Andrew Berg seconded the motion. The motion passed unanimously.

The group thanked Theva for her hard work in leading the short circuit model build.

- Agenda Item 3 – 2019 TPL Dynamic Models (Approval Item):
Nate Morris introduced the group to the 2019 TPL dynamic model set agenda item. Nate asked Sunny Raheem to give a summary of the recent activities for this project. Sunny provided the group the GlobalScape location of the proposed final models, important notes, and supporting file names with descriptions. The group voiced concerns for the structure of the modeling GlobalScape folders. The group discussed GlobalScape folder enhancements such as identify if the software has the ability to sort/filter with metadata attributes. Staff communicated that they are working with the GlobalScape admins to restructure the folder structure in a manner that it will be able to maintain itself throughout multiple annual builds. The group discussed the schedule impacts if the models were not approved during this meeting. Staff communicated the models are based on the previously approved 2018 MDWG dynamic models. Staff reminded the group of the limited scope of change from the 2018 MDWG dynamic models that are already approved. Staff recommended MDWG approve the models as final.

Motion: John Boshears motioned to approve 2019 TPL dynamic models as posted. Reené Miranda seconded the motion. During the discussion of the motion, Andrew Berg mentioned that MRES does not see any major differences from the 2018 MDWG dynamic model sets. The motion passed unanimously.

Action Item: Check with GlobalScape admin to see if there is possibility of meta data filtering
- **Agenda Item 4 – MDWG Manual Language (Approval Item)**
  Michael Odom presented the recent MDWG proposed manual language updates. The group reviewed the changes to the aux load and switched shunt sections. The group discussed the terminology in the switch shunt section in great depth. Group members asked for more clarification for fixed, automatic, and variable settings for switched shunts. The group mentioned the terminology could be clearer to avoid potential confusion for new modelers. Jerad Ethridge reminded the group that the switched shunt adjustment to the base models could have impacts to study analysis such as TPL-001-4. After a lengthy discussion, the group determine additional discussion was warranted within their own shops. Staff agreed to reach out to the SPP groups that deal with ITP/TPL assessments to gather their thoughts. Jeremy Harris asked if load tap changers on transformers should be updated based on the switched shunt recommendation. Joe Williams mentioned the change could require additional annual data information.

**Agenda Item 5 – Administrative Items:**

- **Agenda Item 5a – Summary of Action Items:**
  - Staff to bring draft GIA milestone language back to the April MDWG Meeting for discussion.
  - Staff to check with GlobalScape Admin to determine if there is possibility of metadata filtering capability.

- **Agenda Item 5b – Future Meetings:**
  Nate Morris provided a recap of the upcoming future meetings.

- **Agenda Item 5c – Adjourn Meeting:**
  Moses Rotich provided a quick reminder to the group about the upcoming PSSE v34.5 version for the 2020 MDWG model series. Moses reminded the group the ITP model updates or corrections should be sent to SPP through RMS.

With no further discussion, Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

**Motion:** Jason Shook motioned to adjourn the meeting. Scott Rainbolt seconded it. The motion passed unanimously.

The meeting adjourned at 10:55AM (CST).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
February 15th: 9:00 A.M. – 11:00 A.M. (CST)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:02 a.m. on February 15th. The SPP Antitrust statement was read to the group at the start of the meeting on February 15th. Nate mentioned that he will have to drop off the call at 9:30am and will request Derek Brown to Chair the remainder of the meeting. Nate mentioned Jeff Crites will be his voting proxy at that time.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

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<thead>
<tr>
<th>MDWG Member</th>
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<th>Proxy</th>
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Additional Guests present:

In addition to WebEx attendance
Joe fults Michael W (ITC)

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<th>Guests</th>
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<tr>
<td>Cho Wang</td>
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-- Agenda Item 1e(i) – Agenda Review(Approval Item):
Nate Morris and Joe Fultz thanked staff for the detailed meeting minutes and material. Nate thanked Sunny Raheem and Moses Rotich for posting meeting minutes in a timely manner. Nate asked the group if they had any modifications to the agenda or issues with the posted material. Sunny mentioned that he would like to redline two upcoming meeting times. The updates are for an education session and a correction to the short circuit focus group meeting.

Nate opened the floor to entertain a motion.

Motion: Derek Brown motioned to approve the agenda as presented during the meeting (FEB15_MM_Attach1 - 1e. MDWG Meeting Agenda 20190215_redline.docx). Scott Schichtl seconded the motion. The motion passed unanimously.

-- Agenda Item 1f(i) – January 8th– 9th, 2019 Meeting Minutes Review(Approval Item):
Nate Morris presented the January 8th - 9th meeting minutes. The group discussed the meeting minutes. The group did not voice any modifications.

Nate opened the floor to entertain a motion.

Motion: Alex Mucha motioned to accept the January 8th-9th 2019 meeting minutes as amended at the meeting (FEB15_MM_Attach2 - 1fi. MDWG Minutes January 8-9, 2019.pdf). Derek Brown seconded the motion. The motion passed unanimously.

-- Agenda Item 1g – Action Items Review:
Sunny Raheem presented an overview of the recently completed and in progress action items. For recently completed items, Sunny mentioned that staff send the MMWG manual link to Siemens PTI for consideration of additional software checks. Sunny stated that staff spoke with Harvey Scribner about iterative monthly/quarterly model builds including the challenges of maintaining and understanding which model set is used for which study. The benefit of the iterative method was have more recent models available throughout the year. Sunny mentioned that CGC will be reviewing the request for sending the end of the year assessment survey to non-voting members.

For in-progress items, Sunny mentioned that staff has reached out to MISO for assistance in gathering short circuit information from MISO TOs. Sunny mentioned that staff has coordinated with SPP GI on inclusion of milestones that will clarify MOD-032 requirements but will keep this item as in progress until the milestone is approved and implemented by SPP Modeling and GI.
- Agenda Item 2 – 2019 MDWG Power Flow Model Series Approval (Approval Item):
Nate Morris introduced the group to the 2019 MDWG power flow model series approval agenda item. Nate asked Moses Rotich to give a summary of the recent activities for this project. Moses provided a summary of the different types of changes received after the 1/11/2019 cut-off date including MOD and a few EDST transactions items. Moses stated that there were a few delivery point changes but the overall load amounts per area did not change significantly after 1/11/2019. Moses mentioned that any corrections found after the finalization process should be posted to the post-processing folder on GlobalScape. Moses mentioned the red tab items in the DocuCheck report should be addressed. Moses stated that there are two steady state voltage checks, SPP Voltage violation and MMWG voltage violations. MMWG voltage violation corrections/fixes are required. Moses thanked the group for participation and noted that he felt the process improved since last year. Moses mentioned that he believed staff received less last minute changes then before. Nate also thanked the group for their participation and recognized the improvements he has observed from the group over the last few years.

Joe Fultz asked about the two new Pgen tabs that appear to be similar in DocuCheck. Moses mentioned the two Pgen tabs present the same information but pull EDST machine names in one list and economic machine names in the other. Derek asked Staff and members how are the models are solving. Moses mentioned the MDWG models were solving well and have a summary in DocuCheck for the number of iterations.

Nate asked if the group they understood the post-processing recommendation by Staff. Moses mentioned he will send an email out to communication the location of the post-processing folder on GlobalScape. Moses asked the for data submitters to provide more clarification on which models the post-processing idevs should be applied to.

Nate open the floor to entertain

**Motion:** Derek Brown motioned to approve the 2019 MDWG power flow model series as final with post processing corrections received to date. Andy Berg seconded the motion. During discussion of the motion, Holli Krizek asked if the Rsource and Xsource correction of a wind farm in Western’s area will be correct. Moses mentioned that he reached out to the GO. Moses said he will try to get it fixed before posting the final models. Sunny mentioned that he will correct it in dynamics if it is not fixed in power flow. **The motion passed unanimously.**

Nate asked Derek Brown to Chair the remainder of the meeting starting at 9:42am (central time). Nate mentioned Jeff Crites will be his voting proxy for the remainder of the meeting.

AI: Moses to send out email for the GlobalScape location of the post-processing folder.
- Agenda Item 3 – 2019 TWG Goals Overview
Sunny Raheem presented the 2019 TWG Goals Overview. Sunny mentioned this presentation went to TWG at the February meeting and he wanted to make MDWG members aware of the goals. Sunny mentioned that MDWG will be task with some of the TWG goals. Sunny mentioned that the MDWG focus groups might be good sources to discuss the modeling of Distributed Energy Resources (DERs) and Energy Storage Resources (ESRs). Sunny commented that SPP is going to meet next week internally to discuss aligning Year 1 with other SMEs before bringing a recommendation back to the MDWG and ITP.

- Agenda Item 3a – Summary of Current Distributed Energy Resource & Energy Storage Resource Efforts
Sunny presented current SPP internal and external efforts underway for DERs and ESRs. The group asked how many storage facilities are being modeled currently. Sunny mentioned that a 20MW battery paired with a wind farm expected to come online this year, which is the first one he is aware of in SPP through the SPP GI process. Moses mentioned there is a NERC SAR out of updating MOD-032 to consider DER as well as remove the LSE term and replace it with Distribution Provider.

Agenda Item 4 – Administrative Items:
- Agenda Item 4a – Summary of Action Items:
AI: Moses to send out email for the GlobalScape location of the post-processing folder.

- Agenda Item 4b – Future Meetings:
Derek Brown provided a recap of the upcoming future meetings.

- Agenda Item 4c – Adjourn Meeting:
With no further discussion, Derek Brown solicited a motion to adjourn the meeting and table the remaining items.

Motion: Scott Schichtl motioned to adjourn the meeting. Jerad Ethridge seconded it. The motion passed unanimously.

The meeting adjourned at 10:10AM (CST).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
Southwest Power Pool, Inc.

MODEL DEVELOPMENT WORKING GROUP

February 15, 2019

Conference Call

• A G E N D A •

9:00 a.m. – 11:00 a.m. (CST)

1. Administrative Items ........................................................................................................... Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. January 8th - 9th, 2019 (Approval Item)
   g. Action Items Review

2. 2019 MDWG Power Flow Model Series Approval (Approval Item).............................................. All (80 mins)

3. 2019 TWG Goals Overview ........................................................................................................... SPP Staff (15 mins)
   a. Summary of Current Distributed Energy Resource &
      Energy Storage Resource Efforts...................................................................................... SPP Staff (5 mins)

4. Administrative Items ............................................................................................................ Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Next Meeting: Conference Call February 28th (9:00 – 11:00am)
         2. Education Session: Node-Breaker Modeling Conference Call March 14th
            (9:00 – 11:00am)
      ii. Manual Task Force:
         1. 2nd, 3rd, and 4th Thursday of each month 9am-11am
      iii. Focus Groups Kick Off Meetings:
         1. Power Flow: March 12th (9:00 – 11:00am)
         2. Dynamics: March 13th (9:30 – 11:30am)
         3. Short Circuit: February 26th & March 26th (9:00 – 11:00am)

   c. Adjourn

Note: The approval items denoted with “***” shall be jointly developed by PC, TP, and MDWG.

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Agenda Item 1 – Administrative Items:

- **Agenda Item 1a and 1b – Call to Order & Antitrust Statement:**
The meeting was called to order at approximately 8:31 a.m. on January 8th & 9th. The SPP Antitrust statement was read to the group at the start of the meeting on January 8th & 9th.

- **Agenda Item 1c and 1d – Attendance and Proxies:**
The following MDWG members and guests attended.

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In addition to WebEx attendance

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<td>Joe Williams</td>
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– **Agenda Item 1e(i) – Agenda Review (Approval Item):**
Nate Morris asked the group if they had any modifications to the agenda or issues with the posted material. Nate communicated that New Year’s Day was seven days before posting. Nate mentioned he communicated to staff that it would be acceptable to post the day after New Year to allow staff time to spend with their families. The group did not voice any concerns.

Nate opened the floor to entertain a motion.

**Motion:** Scott Schichtl motioned to approve the agenda as presented during the meeting (JAN8_MM_Attach1 - 1e. MDWG Meeting Agenda 2019010809.docx). Reené Miranda seconded the motion. The motion passed unanimously.

– **Agenda Item 1f(i) – December 6th, 2018 Meeting Minutes Review (Approval Item):**
Nate Morris presented the December 6th meeting minutes. The group discussed the meeting minutes. The group did not voice any modifications.

Nate opened the floor to entertain a motion.

**Motion:** Alex Mucha motioned to accept the December 6th, 2018 meeting minutes as amended at the meeting (JAN8_MM_Attach2 - 1fi. MDWG Minutes December 6, 2018.pdf). Scott Schichtl seconded the motion. The motion passed unanimously.

– **Agenda Item 1g – Action Items Review:**
Sunny Raheem presented an overview of the recently completed and in progress action items. Sunny mentioned that staff will provide a status update on action item #22 at the current meeting. Sunny asked Moses Rotich to provide an update on the action item #2. Moses provided an updated on his recent communication with tier 1 entities. Moses mentioned that he has started reaching out to different software vendors to determine if their software can import and export short circuit models from other software platforms. Andrew Berg stated that MISO should have a list of bus number mapping for their footprint that could be helpful in this effort.

**Action Item:** Staff to reach out to MISO modeling staff to gather the bus mapping data.
- Agenda Item 2 – Model Series Updates:

- Agenda Item 2a – Power Flow:

- Agenda Item 2ai – 2019 MDWG:
Moses Rotich provided an update for the current status of the 2019 MDWG power flow models. Moses gave kudos to the active data submitters that participated during the model build so far. Moses mentioned he received better responses from Generator Owners (GO) in this build than past builds. Moses believes education and training has helped with increase of participation from GOs. Nate Morris asked whether the quality of data has improved during this model build. Moses stated that he believes the data quality has improved, especially the transactions coordination.
Moses mentioned that some of the model build tools require some time to learn, but they do provide a benefit to the model build. Nate Morris mentioned that SPP will have an annual on-boarding for members for the 2020 MDWG model build. Nate mentioned that GOs might not be as aware as other modeling data submitters. Nate mentioned it would be good for staff to reach out to them to increase awareness.

Reené Miranda asked about an update on GO coordination as to identifying the Data Submitter and Transmission Provider as part of the GIA negotiations. Sunny Raheem mentioned that modeling staff is meeting with the GI group next week to start the coordination effort.

Action Item: Staff to reach out to GOs to increase awareness about the annual on-boarding event.

- Agenda Item 2ai1 – MDWG Report Card:
Nate Morris presented an overview of the MDWG report card. Nate mentioned he is noticing an improvement on model updates. Nate mentioned it is easier to update the TWG when models are actively being updated. Nate communicated the importance for sending in the “no change” emails as required by MOD-032. Michael Wegner asked if it was ideal to communicate the changes every pass. Nate Morris acknowledged this is the best way to communicate changes. Jerad Ethridge asked if advance communication for new DocuCheck changes can be communicated earlier with MDWG. Sunny Raheem mentioned the MDWG focus groups could be a good avenue for vetting the DocuCheck updates. Joe Fultz asked if the pass 4 exceptions are included in the report card. Moses mentioned the report card will be updated in the final pass for exceptions. Nate Morris asked the group about EDST and its impact to the current model build. Martin Green mentioned the process is improving but still has some improvement. Joe Williams mentioned that EDST emails are not clear and too frequent.

- Agenda Item 2aii – ITP:
- Agenda Item 2aii1 – 2020 ITP Update:
Sherri Maxey provided an overview of the 2020 ITP scope development, power flow models, short circuit, load review, generation review schedules. Sherri emphasized the timelines and of the different milestones and their dependence on the MDWG power flow models. Sherri asked Nate how frequently the ITP updates should be presented to MDWG. Nate mentioned maybe a written report every other month. Sherri mentioned that there will be overlaps in ITP in June/July. Sherri mentioned MDWG members would have to coordinate with their TWG and ESWG representatives especially during the overlapping timeframes to ensure communication is efficient.
- Agenda Item 2aii2 – 2020 ITP Generation and Load Review Update:
Clayton Mayfield provided an overview for planned retirement inconsistencies for the 2020 ITP Base Reliability (BR) Power flow models and the 2020 ITP Generation Review workbook. He also presented the 2020 ITP Generation and Load Review next steps. Nate Morris mentioned the complexity associated with announcing generator retirements and how they are modeled in the various model sets. Clayton mentioned that this effort is a re-verification. Joe Fultz asked how long a generator retirement is looking out. Nate mentioned it is required for reporting every 3 years.

- Agenda Item 2b – 2019 MDWG Short Circuit:
Theva Coleman provided an update for the 2019 MDWG short circuit model build. Theva mentioned that Pass 1 is posted and ready for stakeholder review.

- Agenda Item 2bi – Schedule Update (Approval Item*):
Moses Rotich provided an overview to the proposed 2019 MDWG short circuit schedule corrections. Moses mentioned that the timelines for Pass 2 did not align with the 2019 power flow schedule. Moses and Sunny mentioned that the end date did not change in the proposed schedule. The group discussed the impacts of approving or not approving the proposed schedule changes.

Nate opened the floor to entertain a motion.

Motion: Jerad Ethridge motioned to approve the changes to the schedule as presented at the meeting (JAN8_MM_Attach3 - 2bi. 2019 series mdwg and 2020 short circuit model build.xlsx). Derek Brown seconded the motion. The motion passed unanimously.

- Agenda Item 2c – 2019 MDWG Dynamics:
Shahrokh Akhlaghi provided an updated on the status of the 2019 MDWG dynamic model build project. Shahrokh mentioned the project will kick off on January 14th. Shahrokh mentioned that SPP will be communicating the unacceptable model set at that time also. The group discussed the need for guidance documentation to be sent to GOs as part of the unacceptable model list. Andrew Berg asked if the unacceptable model list will apply to BES and/or non-BES. Sunny Raheem mentioned that SPP can request it for facilities applicable to MOD-032. Outside of the MOD-032 would require additional requirements for reinforcement.

- Agenda Item 3 – Break:

- Agenda Item 4 – SPP Compliance Updates:
- Agenda Item 4a – TPL-001-5 Standard Update:
Jonathan Hayes presented the TPL-001-5 requirements and communicated the changes from TPL-001-4. The group discussed a list or criteria changes are going to be communicated to other working groups. The group discussed how outages will be modeled and how to handle situations where generator shortfall might occur. The group discussed approach to how the standard should be vetted with the SPP working groups including Dynamic Load Task Force (DLTF), TPL Task Force (TPLTF), MDWG, and Transmission Working Group (TWG).
- **Agenda Item 5 – Lunch:**

- **Agenda Item 6 – PSSE Version 34 Model Demonstration:**
  Frank McElvain introduced the Siemens PTI team, Krishnat Patil, Jayapalan Senthil, Joseph Hood, and Carlos Vargas. Frank led the discussion for PSSE version 34 model demonstration effort. Krishnat presented the short circuit overview including short circuit activities, fault calculations, and node breaker compatibility. Jayapalan introduced the new features to PSSE version 34, dynamic engine enhancements, new dynamic models, and Distributed Resource (DER) modeling. Joseph Hood provided a summary of recent power flow additions including, robust solution options, node breaker modeling, and ACCC with node-breaker contingencies. Staff and the group asked if PSSE v34 will have additional data checks built in for power flow. Staff mentioned the Eastern Interconnection Multi Model Development Regional Working Group (MMWG) has data checks in their manual that would be helpful to have as part of the software.

**Action Item:** Staff to send MMWG manual data checks to Siemens.

- **Agenda Item 7 – Revision Request Update:**
  - **Agenda Item 7a – AQ RR 262:**
    Joshua Ross presented and overview of the Attachment QA process and business practices. Joshua mentioned the current state of the AQ RR 262 as it relates to stakeholder review. Josh mentioned the purpose of the RR is to expedited planning process to assess changes to delivery points and identify any necessary upgrades to accommodate those delivery points. The group discussed if load 3 years out is required to go through AQ. Joshua mentioned that members should caution on the safe side and submit to AQ. Joe Fultz asked how a service agreement is terminated. Joshua mentioned that AQ does rely on members for a lot for those updates. The group mentioned that improvements to the screening criteria were improved that would go a long way in the actual intent of the study.

- **Agenda Item 8 – Break:**

- **Agenda Item 9 – Engineering Data Submission Tool (EDST) Update:**
  Hagen Boehmer presented the EDST update. Hagen provided insight on two items, Dashboard and Bulk Upload capability. Hagen mentioned the goal for the dashboard update is to provide an interactive summary for changeset history. Hagen mentioned the purpose for the bulk upload was to have capability of uploading excel spreadsheet to a changeset. The group discussed the best approach and format for uploading. The group largely agreed to follow the download template format for uploading. The group asked how enhancements should be communicated to SPP. Sunny Raheem mentioned that it would require at least a one year implementation lead time notice for major updates. Eddie Watson mentioned that for minor updates they can be worked into upcoming releases and may not require a one year fix. Moses Rotich mentioned that “hot fixes” can be pushed out quicker.
- Agenda Item 10 – 2019 Power Flow Workshop:
Nate Morris described the scope of the 2019 power flow workshop item to the group. Nate mentioned that this time is really for data submitters to ask SPP questions about the current 2019 MDWG power flow model build process.

Jerad Ethridge asked about the remote voltage regulating generating settings and if they should be fixed. The group discussed details of the generating facility and how the voltage issue could be resolved. Derek Brown suggested that the tab color could be changed for this in DocuCheck if it is not required. Moses agreed to explore the possibility of changing the tab color.

The group discussed the need for standard format for data request, historical model correction database, and calculation template for equivalence of wind farms.

The meeting ended day 1 discussion at 4:31pm with day 2 resuming at 8:30am (CST).

- Agenda Item 11 – Total Number of Model Reduction Effort:
- Agenda Item 11a – Status Update:
Michael Odom presented the status of the total number of model reduction effort. Michael presented the background information for the effort, major differences between ITP BR and MDWG models, challenges to address, and next steps. Martin Green asked if SPP has considered quarterly model builds like ERCOT. Michael said that this is something staff can look at.

Action Item: Check with previous modeling staff to see what challenges were encountered in the iterative model build approach.

Reené Miranda asked if the base case solutions are fixed outside of the ITP process in this staff option for eventually removing the need for MDWG models. Michael mentioned they would be. The group discussed why MMWG requires base case violations to be resolved before the associated ITP study is completed. The group discussed reality vs planned considerations for base case corrections.

Liam Stringham mentioned that Sunflower utilize the MDWG for all their studies and ITP for coming up with DPPs. Furthermore, ITP does not contain a year 0 model set which is used for operational studies so Sunflower would not be in favor of this approach. Derek Brown mentioned ITP only reflects firm service whereas MDWG and BA contain non-firm which reflects what the market presents. Derek mentioned TPL-001-4 states that the models should reflect as expected system conditions, which is the market, and MDWG meets those requirements. Derek stated TO planned projects not being in ITP will require a change in the MOD matrix to include projects expected to go in-service or are already in-service regardless of if SPP disagrees. Jason Hofer agreed with Derek and Liam. Reené commented that Southwestern Public Service has to utilize model with their non-coincident peak so the BA would not be a good case for compliance. Martin commented that American Electric Power uses the year 0. Martin mentioned fixing dispatch would be a good step towards reducing models.
- Agenda Item 11b – Members’ Modeling Needs Survey Results:
Sunny Raheem presented the scope and results from the Member’s Modeling Needs Survey for MDWG models. The group discussed the results of survey and how many members utilize specific seasonal models. The group debated the possibility of benefits and considerations of proposing building only member minimum compliance and operation needs. The group discussed situations where the ITP model could be leveraged instead of building the associated seasonal MDWG model. Staff presented the results for different compliance timelines and considerations. Sunny mentioned that the detailed responses to the last few questions are included in the background material.

- Agenda Item 12 – MDWG Manual:
- Agenda Item 12a – Language Approval (Approval Item*):
Michael Odom led the discussion for the recent language approval. Michael outlined Section 8’s purpose, format, and benefit. The group reviewed the steady state language changes as linked through Section 8 updates. Michael asked if the group like the format of Section 8. The group at large agreed that they liked the format and benefit it provides for MOD-032 requirements.

Nate opened the floor to entertain a motion.

Motion: Andrew Berg motioned to approve the changes to the manual as presented at the meeting (JAN8_MM_Attach4 - 12a. SPP Model Development Procedure Manual 2018 v2.1_Working.docx). Jason Hofer seconded the motion. The motion passed unanimously.

- Agenda Item 13 – 2018 SPP Working Group Survey:
Sunny Raheem presented the results of the 2018 MDWG assessment survey. Sunny mentioned that he felt like the group was improving over the years greatly. Sunny noted that there are many areas in good standing, but there is one area for improvement. Sunny mentioned that staff and the MDWG focus groups will help improve preparation of meeting material for member participation. Sunny mentioned that onboarding in 2019 will help easy new modeling resources for members get up to speed on SPP model builds. Sunny commented on the response for more meeting minute details to be included. Sunny mentioned that the meeting minutes are posted twice which allows additional edits to be introduced before the approval is requested. Nate Morris added that he is pleased with the improvements and work that the group completed in 2018. Nate mentioned that he would like continue to provide improve the highlighting of important material for heavy discussion, help members prepare to the meeting, and continue to help facilitate discussion to cover the full agenda. The group discussed if the survey can be sent out to non-voting members.

Action Item: Staff to check internally with communications to see if end of the year assessment can be expanded to non-voting members.
- **Agenda Item 14 – MDWG Focus Group Updates:**
  - **Agenda Item 14a – Dynamics:**
    Marcus Moor provided an update for recent activities at the MDWG Dynamics Focus Group including the EIPC Frequency Response effort, model reduction, MDWG manual edits, applicability to non-BES for acceptable dynamic models, and agenda development for the next meeting.

- **Agenda Item 14b – Power Flow:**
  Jerad Ethridge provided an update of recent activities based on the previous power flow focus group agenda including generation retirements, EDST improvements discussions, and future FAC-002-2 education.

- **Agenda Item 14c – Short Circuit:**
  Reené Miranda provided an update on recent short circuit meetings and scheduled upcoming meetings.

**Agenda Item 15 – Administrative Items:**
- **Agenda Item 15a – Summary of Action Items:**
  - Staff to reach out to MISO modeling staff to gather the bus mapping data.
  - Staff to reach out to GOs to increase awareness about the annual on-boarding event.
  - Staff to send MMWG manual data checks to Siemens.
  - Check with previous modeling staff to see what challenges were encountered in the iterative model build approach.
  - Staff to check internally with communications to see if end of the year assessment can be expanded to non-voting members.

- **Agenda Item 15b – Future Meetings:**
  Nate Morris provided a recap of the upcoming future meetings.

- **Agenda Item 15c – Adjourn Meeting:**
  With no further discussion, Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

**Motion: Reené Miranda motioned to adjourn the meeting. Jerad Ethridge seconded it.**
**The motion passed unanimously.**

The meeting adjourned at 11:39AM (CST).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
Southwest Power Pool, Inc.

MODEL DEVELOPMENT WORKING GROUP

January 8-9, 2019

OGE Offices, Leadership Square Build – 14th Floor, LSN 1406
211 North Robinson, Oklahoma City, Oklahoma 73102

• A G E N D A •

8:30 a.m. – 5:00 p.m. (CST)
8:30 a.m. – 12:00 p.m. (CST)

1. Administrative Items .......................................................................................................................... Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. December 6th, 2018 (Approval Item)
   g. Action Items Review

2. Model Series Updates
   a. Power Flow
      i. 2019 MDWG ................................................................. Moses Rotich (20 mins)
         1. MDWG Report Card ................................................. Moses Rotich (15 mins)
      ii. 2020 ITP Update ....................................................... Sherri Maxey (15 mins)
         2. 2020 ITP Generation and Load Review Update .... Clayton Mayfield (30 mins)
   b. 2019 MDWG Short Circuit .................................................... Theva Coleman (10 mins)
      i. Schedule Update (Approval Item*) ................................. Moses Rotich (20 mins)
   c. 2019 MDWG Dynamics ........................................ Shahrokh Akhlaghi/Sunny Raheem (5 mins)

3. Break ........................................................................................................................................ (15 mins)

4. SPP Compliance Updates
   a. TPL-001-5 Standard Update ............................................... Jonathan Hayes (25 mins)

5. Lunch ........................................................................................................................................ (60 mins)

6. PSSE Version 34 Model Demonstration ....................................................... Siemens PTI Staff (120 mins)

7. Revision Request Update
   a. AQ RR 262 ........................................................................ Joshua Ross (15 mins)

8. Break ........................................................................................................................................ (15 mins)

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
9. Engineering Data Submission Tool (EDST) Update ........................................Hagen Boehmer (15 mins)
10. 2019 Power Flow Workshop ......................................................................................... All (60 mins)
11. Total Number of Model Reduction Effort
   a. Status Update ........................................................................................................ Michael Odom (30 mins)
   b. Members’ Modeling Needs Survey Results .................................................. Sunny Raheem (30 mins)
12. MDWG Manual
   a. Language Approval (Approval Item*) .............................................................. Michael Odom (45 mins)
13. 2018 SPP Working Group Survey ............................................................................. Sunny Raheem (15 mins)
14. MDWG Focus Group Updates
   a. Dynamics ........................................................................................................... Marc Moor/Sunny Raheem (15 mins)
   b. Power Flow ....................................................................................................... Jerad Ethridge/Moses Rotich (15 mins)
   c. Short Circuit ........................................................................................................ Reené Miranda/Michael Odom (15 mins)
15. 2019 Power Flow Workshop ......................................................................................... All (30 mins)
16. Administrative Items ................................................................................................. Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Face-to-Face
            a. June/July 2019 Onboarding
            b. October 2019 Face-to-Face
            c. January 2020 Face-to-Face
         2. Discuss Feb 2019 – Jan 2020 monthly calls
      ii. Manual Task Force:
         1. 2nd, 3rd, and 4th Thursday of each month 9am-11am
      iii. Focus Groups Kick Off Meetings:
         1. Power Flow: February 12th (9:00 – 11:00am)
         2. Dynamics: February 13th (9:30 – 11:30am)
         3. Short Circuit: February 26th (9:00 – 11:00am)
      c. Adjourn

Note: The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
December 6th: 9:00 A.M. – 12:00 P.M. (CST)

**M I N U T E S**

**Agenda Item 1 – Administrative Items:**

- **Agenda Item 1a and 1b – Call to Order & Antitrust Statement:**
  The meeting was called to order at approximately 9:01 a.m. on December 6th. The SPP Antitrust statement was read to the group at the start of the meeting on December 6th.

- **Agenda Item 1c and 1d – Attendance and Proxies:**
  The following MDWG members and guests attended.

**MDWG Members present:**

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<th>Present</th>
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<td>Nate Morris</td>
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<td>Empire District Electric Company</td>
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<td>Derek Brown</td>
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<td>Dustin Betz</td>
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<td>Jerad Ethridge</td>
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<td>Oklahoma Gas &amp; Electric</td>
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<td>Joe Fultz</td>
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<td>Grand River Dam Authority</td>
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<td>Holli Krizek</td>
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<td>Reené Miranda</td>
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<tr>
<td>Sunny Raheem</td>
<td>YES</td>
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<td>Southwest Power Pool, Inc.</td>
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**Additional Guests present:**

**In addition to WebEx attendance**

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<tr>
<td>Martin Green, Scott Rainbolt</td>
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<td>Jordan Lamb</td>
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<td>Jeff Crites</td>
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<td>Evergy Companies</td>
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<td>Dona Parks, Kiet Nguyen</td>
<td>Grand River Dam Authority</td>
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<td>Charles Aleman</td>
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<td>Mitch Krysa</td>
<td>Independence Power &amp; Light</td>
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<td>Michael Wegner</td>
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<td>Armin Sehic</td>
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<td>Oklahoma Corporation Commission</td>
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<td>Dave Sargent</td>
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<td>Chris Colson, Garrick Nelson</td>
<td>Western Area Power Administration</td>
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<tr>
<td>Joe Williams</td>
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– **Agenda Item 1e(i) – Agenda Review (Action Item):**
Nate Morris asked the group if they had any modifications to the agenda or issues with the posted material. The group did not voice any modifications. Jerad Ethridge requested to add an agenda discussion topic for recent the renewable dispatch communicate to data submitters from SPP. The group reviewed the agenda and agreed to place this new item as 4a.i.

Nate opened the floor to entertain a motion.

**Motion:** Dustin Betz motioned to approve the agenda as edited during the meeting (DEC6_MM_Attach1 – 1e. MDWG Meeting Agenda 20181206_redline.docx). Derek Brown seconded the motion. The motion passed unanimously.

– **Agenda Item 1f(i) – November 1st, 2018 Meeting Minutes Review(Approval Item):**
Nate Morris presented the November 1st meeting minutes. Sunny Raheem mentioned that he had a mistake in the members attendance records from the November 1st meeting. Sunny mentioned he redlined the correction to show Scott Schichtl as present. The group discussed the meeting minutes. The group did not voice any additional modifications.

Nate opened the floor to entertain a motion.

**Motion:** Jerad Ethridge motioned to accept the November 1st, 2018 meeting minutes as amended at the meeting (DEC6_MM_Attach2 – 1fi. MDWG Minutes November 1, 2018_redline.pdf). Jason Shook seconded the motion. The motion passed unanimously.

– **Agenda Item 1g – Action Items Review:**
Sunny Raheem presented an overview and updates of the recently completed and in progress action items. Sunny mentioned that staff would be ready to provide a status update on action item #22 at the January MDWG face-to-face meeting. However, the final recommendation will not be ready at the January meeting. Staff currently plans to have the final recommendation ready for the 2020 MDWG model build discussions. The group did not voice any modifications.
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**- Agenda Item 2 – 2018 MDWG Dynamics Full and Reduce Case Benchmarking:**

**- Agenda Item 2a – 3rd Tier and Beyond Representation in Reduced Cases Overview:**

Sunny Raheem presented the 3rd tier and beyond representation in the dynamic reduced cases. Sunny mentioned the objective for this agenda item is to provide a high level overview of how the models are currently reduced and to collect feedback for future MDWG dynamic focus group discussions on the topic. Sunny provided background information on differences between full and reduced dynamic models. Sunny stated that the reduced cases do not modify the SPP, MRO footprint, 1st tier, and 2nd tier areas. 3rd tier and beyond is represented by boundary conditions on the 2nd to 3rd tier tie-lines. Sunny presented a visual graph representing the approximate area of the boundary in the reduce cases. Sunny thanked Dustin Betz for the idea of building a visual representation to demonstrate the boundary. Some members asked for more clarification on the boundary machines. Sunny mentioned that the boundary machines are placed on the 3rd tier side of each 2nd – 3rd tier tie lines with a GENCLS model including typical parameters. Sunny mentioned the full detailed list of areas that are reduced or represented by boundary machines are included in the background material under 2a. 3rd Tier and Beyond Representation in Reduced Cases Overview.xlsx. The group discussed the reduction overview process and did not voice any significant concerns over the current approach.

**- Agenda Item 2b – Benchmarking Results & 2019 Build Recommendation (Approval Item):**

Sunny Raheem presented the scope of the Benchmarking Results & 2019 Build Recommendation agenda item. Sunny presented the objective of comparing fault responses between the full and reduced seasonal cases. Sunny mentioned that staff is interested in determining if the full cases are a continual need after reviewing the benchmarking results. Sunny thanked the participates listed in the presentation for their feedback and review as part of the benchmarking effort. Sunny provided an overview of the benchmarking effort including consideration of seasonal models, contingencies, monitored channels, and results for comparison. Sunny mentioned that staff did review majority of the results and identify some differences. However, the differences were comparable in magnitude and did not provide different general responses. After the scope overview presentation, Nate opened the floor for stakeholder and member input.

Chris Colson commented that WAPA has not fully reviewed all the benchmarking results. Chris mentioned that WAPA is in favor of moving forward with reduced cases with consideration of continuing to build for year 1 and 5 off-peak full dynamics case based on the benchmarking results reviewed so far. Derek Brown asked staff how building full cases would affect the 2019 MDWG schedule with a mid-September final posting date. Sunny Raheem mentioned staff could accommodate up to two full cases in the schedule for a transition year, but any additional full cases beyond that point could affect the mid-September posting. Marcus Moor thanked Sunny Raheem and SPP Staff for performing the results and voiced support for moving to reduced cases. Marcus mentioned that Evergy is also in favor of maintaining a small set of full cases for further benchmarking. Marcus mentioned the reduced cases provide comparable responses with faster execution time. Dustin Betz also thanked SPP staff and mentioned NPPD is in favor of moving to the reduced cases but recognized that there is a need for a transition year to capture some concerns of members that still need a few full cases.
Nate Morris asked Chris Colson if he could provide more insight on his need for the full cases. Chris mentioned that WAPA has concerns with MISO moving to TSAT for dynamics and SPP moving only to reduced cases. Chris mentioned he could see the full case need possibly transitioning out in the future from WAPA if additional benchmarking provides comparable results.

Andy Berg asked with MOD-033-1 standard not being in effect for a long time, does going to a reduced model have an effect if an event occurs. Chris Colson answered that since MOD-033-1 is applicable to the PC, the PC has probably done its due diligence. He also mentioned that in the WEST, WAPA is doing model validation on a full case. Sunny Raheem commented that since MOD-033-1, dynamic validation can be limited to a local event and validation, SPP has considered this and does not see a need for a MDWG full case. Sunny mentioned that SPP would still have the MMWG full eastern interconnection models available also.

Marcus Moor asked when doing the model build, does SPP use the MMWG models for the latest external data. Sunny Raheem mentioned that staff does use the MMWG models for the latest external data. Moses Rotich mentioned that the latest MMWG models are posted on GlobalScape and access can be granted if a request is sent to SPP.

The group discussed the benefits of building reduced only or full cases. Staff mentioned that the full seasonal cases are available under the MMWG effort. The reduced cases provide a more stable response and faster simulation execution time.

Nate opened the floor to entertain a motion.

**Motion:** Derek Brown made the motion to approve the MDWG recommendation presented on the screen (DEC6_MM_Attach3 - 2b. Benchmarking Results & 2019 Build Recommendation_redline.pptx) to build previously approved reduced models and two (20S and 20L) full models for the 2019 MDWG Dynamic model set. Dustin Betz seconded it. The motion passed unanimously.
- Agenda Item 3 – 2019 MDWG Dynamics Model Build Schedule (Approval Item*):
Sunny Raheem presented the 2019 MDWG Dynamics Model Build Schedule. Sunny mentioned that there are two schedules posted, but recommend only discussing the reduced model schedule since the approval in the previous agenda item. Sunny mentioned the schedule is similar to the original 2018 MDWG schedule with consideration of one new schedule item and one removed items. Sunny mentioned the model reduction would be conducted on the front end, therefore limiting the model reduction item later in the schedule. The new schedule item is communicating the unacceptable dynamic model list to GOs. Reené Miranda asked if it is possible to send out the list of unacceptable models before the start of the 2019 MDWG dynamic model build schedule to allow GOs more time. Sunny mentioned that staff could try to see if they can send a request out before the start of the project. Nate Morris asked who at SPP would be taking lead the 2019 MDWG model build. Sunny answered that he would be lead with Shahrokh Akhlaghi as the backup. Sunny mentioned that Shahrokh would probably be leading the dynamic model build effort in the future.

Nate opened the floor to entertain a motion.

Motion: Derek Brown motioned to approve 2019 MDWG schedule as presented at the meeting (DEC6_MM_Attach4 - 3. 2019_MDWG_Dynamics_Model_Build_Draft_Detailed_Schedule_ReducedOnly.xlsx). John Boshears seconded the motion. The motion passed unanimously.

Reené Miranda asked if the GlobalScape folders could be set up prior to the start of the 2019 MDWG dynamic model build. Sunny mentioned he will work with SPP IT to initiate the folder request before the start of the project.

Action Item: Staff to work on setting up 2019 MDWG dynamic project GlobalScape folders prior to the project starting.

- Agenda Item 4 – 2019 MDWG Build:

- Agenda Item 4a – Power Flow Build Update:
Moses Rotich provide the following power flow build updates and suggestions:
  - 2020 ITP Load and Generation Review updates dependent on 2019 MDWG power flow
    - Recommendation for data submitters to coordinate with their resource planners to ensure alignment between the MDWG power flow model and 2020 ITP load & generation review.
    - Verification of load ownership
    - 2020 ITP power flow model build to finalize around November/December timeframe. The BA model is schedule to be finalized in January.
    - Section 10.3 to be used for any updates to the models after 1/11/2019 due to impacts on the economic models.
  - 2019 MDWG Model Build
    - Staff cannot recommend approving models when certain reoccurring issues are still showing up in Pass 3.
    - New data or fixes for persistent issues submitted after 1/11/2019 will be marked late.
Concerns about unscheduled passes. Staff recommends MDWG to start considering voting on unscheduled passes.

Reené Miranda commented that SPS is observing several solving issues where shunts were toggling and causing issues with solution convergence. Marcus Moor suggested that shunt interaction in the models be limited to 10 iterations to help with solution convergence. Moses Rotich mentioned that staff will look into that recommendation.

- External Load coordination
  - Improving coordination of external loads with external entities to eliminate noticeable differences at MMWG.
- MOD-032 R3 requirement:
  - Moses encourages entities applicable to MOD-032 to send SPP a notification via email to ensure MOD-032 compliance evidence.

Reené Miranda suggested SPP could invoke MOD-032 R3 on entities not participating well in the model build rather than doing it to everyone since this alternate approach brings extra responsibilities.

- EDST
  - All tabs (load details, generator details, etc) need to be populated and/or reviewed in each pass.
  - SPP will open EDST early for Data Submitters to populate the tabs.

Dona Parks suggested staff to add additional clarification in the EDST user guide for the different sections.

**Action Item: EDST User Guide clarification for the different sections of MDWG (branches, 2-winding transformers, etc.)**

- Report Card
  - Staff is tracking participation and late data submittals that could end up affecting other data submitters.
  - Will be presented at different working groups.

Moses Rotich mentioned that Siemens PTI might be available to present a PSSE version 34 demonstration in preparation for the 2020 MDWG model build.

**- Agenda Item 4ai – Renewable Dispatch Discussion:**
The group discussed the impacts of the recent renewable dispatch amounts provided by SPP. Michael Odom mentioned that the data posted mainly affects the fall seasons and a few other models. He also mentioned that data submitters who can correct the data by the current pass deadline this week can do so. Otherwise, data submitters can send in their updates after pass 4 models are posted. Nate Morris asked if anyone had concerns with this approach. Dustin Betz said NPPD had no concerns. Liam Stringham voiced concerns as to the adjustments have been required at every pass for updated renewable dispatch amounts.
- **Agenda Item 4b – Short Circuit Build Update:**
Theva Coleman presented the Short Circuit Build Update. Theva mentioned that SPP will post pass 1 of the short circuit model build on 12/14/2018. The group did not voice any concerns.

- **Agenda Item 5 – MDWG Governing Guidance Documents:**
  - **Agenda Item 5a – Membership Guidance Revisions:**
Sunny Raheem presented the most recent version of the MDWG membership guidance document. Sunny mentioned this document is intended to be a reference. Sunny also provided an update on the MDWG Charter revisions that were recently approved by MDWG. Sunny mentioned that the member revision for up to 24 members would go to the TWG in December. If approved by TWG then the Charter revisions will go MOPC in January for approval and then on to CGC. The group did not voice any concerns.

- **Agenda Item 6 – Break:**

- **Agenda Item 7 – MDWG Manual:**
  - **Agenda Item 7a – Language Approval (Approval Item***):
Michael Odom presented the Non-conforming and On-Peak/Off-Peak model MDWG manual language updates to the group.

  Michael presented the Non-confirming load language changes. Jason Shook said he did not completely understand what this language is trying to accomplish. Jason mentioned that this language seemed to speak to internal load forecasting. The 50/50 load forecast should be able to cover non-scalable loads that do not change. Reené Miranda mentioned that SPS uses the approached provided in the language for loads that do not change. SPS allocates their BA load on a zone basis first and the non-scalable loads are set.

  During discussions, MDWG members recommended taking the non-conforming load language changes to the MDWG power flow focus group.

**Action Item:** Take Non-Conforming Load language to MDWG Power Flow Focus Group

Michael presented the On-Peak/Off-Peak Models language changes. The group did not voice concerns pertaining to On-Peak/Off-Peak Models language changes.

Nate opened the floor to entertain a motion.

**Motion:** Jason Shook motioned to approve On-Peak/Off-Peak language as presented at the meeting (DEC6_MM_Attach5 - 7a. SPP Model Development Procedure Manual 2018 v2.0.docx). Marcus Moor seconded the motion. The motion passed unanimously.
- Agenda Item 8 – MDWG Focus Group Updates:
- **Agenda Item 8a – Dynamics:**
  Marcus Moor provided an update for recent activities at the MDWG Dynamics Focus Group including UFLS overview presented by Scott Jordan, MDWG manual edits, and agenda development for the next meeting.

- **Agenda Item 8b – Power Flow:**
  Moses provided an update of recent activities included MDWG dispatch methodology, load modeling, upcoming PSSE version selection from MMWG, and MOD testing.

- **Agenda Item 8c – Short Circuit:**
  Reené Miranda provided an update on recent short circuit meetings.

Agenda Item 9 – Administrative Items:
- **Agenda Item 9a – Summary of Action Items:**
  
  - Staff to work on setting up 2019 MDWG dynamic project GlobalScape folders prior to the project starting.
  - Staff to add EDST User Guide clarification for the different sections of MDWG (branches, 2-winding transformers, etc.)

- **Agenda Item 9b – Future Meetings:**
  Nate Morris provided a recap of the upcoming future meetings.

- **Agenda Item 9c – Adjourn Meeting:**
  With no further discussion, Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

  Motion: Jason Shook motioned to adjourn the meeting. Alex Mucha seconded it. The motion passed unanimously.

  The meeting adjourned at 12:03PM (CDT).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
December 6, 2018
Net Conference
• A G E N D A •
9:00 a.m. – 12:00 p.m. (CST)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. November 1st, 2018 (Approval Item)
   g. Action Items Review

2. 2018 MDWG Dynamics Full and Reduce Case Benchmarking
   a. 3rd Tier and Beyond Representation in Reduced Cases Overview ... Sunny Raheem (15 mins)
   b. Benchmarking Results & 2019 Build Recommendation (Approval Item) ....... All (25 mins)

3. 2019 MDWG Dynamics Model Build Schedule (Approval Item) ......................... All (20 mins)

4. 2019 MDWG Build
   a. Power Flow Build Update ......................................................... Moses Rotich (15 mins)
      a.i. Renewable Dispatch Discussion ......................................................... All
   b. Short Circuit Build Update ......................................................... Theva Coleman (10 mins)

5. MDWG Governing & Guidance Documents
   a. Membership Guidance Revisions ......................................................... All (20 mins)

6. Break ................................................................. (10 mins)

7. MDWG Manual
   a. Language Approval (Approval Item) ................................................. Michael Odom (30 mins)

8. MDWG Focus Group Updates
   a. Dynamics ................................................................. Marc Moor/Sunny Raheem (5 mins)
   b. Power Flow ................................................................. Jerad Ethridge/Moses Rotich (5 mins)
   c. Short Circuit ................................................................. Reené Miranda/Michael Odom (5 mins)

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9. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Face-to-Face, OKGE in OKC January 8 (8am-5pm) – 9 (8am-12pm)
         2. Discuss Feb 2019 – Jan 2020 monthly calls
      ii. Manual Task Force:
          1. 2nd, 3rd, and 4th Thursday of each month 9am-11am
      iii. Focus Groups Kick Off Meetings:
          1. Power Flow: December 11th (9:00 – 11:00am)
          2. Dynamics: December 12th (9:30 – 11:30am)
          3. Short Circuit: December 18th (9:00 – 11:00am)
   c. Adjourn

Note: The approval items denoted with *** shall be jointly developed by PC, TP, and MDWG.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
November 1st: 9:00 A.M. – 12:00 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:01 a.m. on November 1st. The SPP Antitrust statement was read to the group at the start of the meeting on November 1st.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

**MDWG Members present:**

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<tr>
<th>MDWG Member</th>
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<th>Proxy</th>
<th>Present</th>
<th>Company</th>
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<tbody>
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<td>Nate Morris</td>
<td>YES</td>
<td></td>
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<td>Empire District Electric Company</td>
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<tr>
<td>Derek Brown</td>
<td>NO</td>
<td>Ryan Baysinger</td>
<td>YES</td>
<td>Evergy Companies</td>
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<td>Dustin Betz</td>
<td>YES</td>
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<td>Nebraska Public Power District</td>
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<td>John Boshears</td>
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<td>City Utilities of Springfield</td>
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<td>Jerad Ethridge</td>
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<td>Oklahoma Gas &amp; Electric</td>
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<td>Joe Fultz</td>
<td>YES</td>
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<td>Grand River Dam Authority</td>
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<tr>
<td>Holli Krizek</td>
<td>NO</td>
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<td>Western Area Power Administration</td>
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<tr>
<td>Reené Miranda</td>
<td>YES</td>
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<td>Alex Mucha</td>
<td>YES</td>
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<td>Oklahoma Municipal Power Authority</td>
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<td>Scott Schichtl</td>
<td>YES</td>
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<td>Jason Shook</td>
<td>YES</td>
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<td>Liam Stringham</td>
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<td>Sunflower Electric Power Corporation</td>
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<tr>
<td>Sunny Raheem</td>
<td>YES</td>
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<td>Southwest Power Pool, Inc.</td>
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Additional Guests present:

In addition to WebEx attendance

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<tr>
<td>Martin Green, Scott Rainbolt</td>
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<td>David Vernier</td>
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<td>Jordan Lamb</td>
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<td>Dona Parks</td>
<td>Grand River Dam Authority</td>
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<td>Charles Alemian</td>
<td>Golden Spread Electric Cooperative</td>
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<td>Mitch Kryat</td>
<td>Independence Power &amp; Light</td>
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<td>Andy Berg, John Weber</td>
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<td>Armin Sehic, Bruce Dool</td>
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<td>Jarrod Wolford</td>
<td>Northeast Texas Electric Cooperative, Inc</td>
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<td>David Duhart, Eddie Watson, Jeff McDiarmid,</td>
<td>Southwest Power Pool, Inc.</td>
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<td>Jonathan Hayes, Michael Odom, Moses Rotich,</td>
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<td>Shahrokh Akhlaghi, Terry Rhoades</td>
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<td>Dave Sargent, Scott Mijin</td>
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<td>Aravind Chellappa, Frank Favela</td>
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<td>Chris Gilden</td>
<td>Tri-State Generation &amp; Transmission</td>
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<td>Joe Williams</td>
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<td>Vahram Stepanyan</td>
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– Agenda Item 1e(i) – Agenda Review (Action Item):
Nate Morris asked the group if they had any modifications to the agenda or issues with the posted material. The group did not voice any modifications.

Nate opened the floor to entertain a motion.

Motion: Jason Shook motioned to adopt the agenda as presented during the meeting (NOV1_MM_Attach1 - 1e. MDWG Meeting Agenda 20181101.docx). Jerad Ethridge seconded the motion. The motion passed unanimously.

– Agenda Item 1f(i) – October 4th, 2018 Meeting Minutes Review (Approval Item):
Nate Morris presented the October 4th meeting minutes. The group discussed the meeting minutes. The group did not voice any modifications.

Nate opened the floor to entertain a motion.

Motion: Jason Shook motioned to accept the October 4th, 2018 meeting minutes as presented at the meeting (NOV1_MM_Attach2 - 1fi. MDWG Minutes October 4, 2018.pdf). Alex Mucha seconded the motion. The motion passed unanimously.

– Agenda Item 1g – Action Items Review:
Sunny Raheem presented an overview of the current action items in particular action items #22 and #25-27. Sunny mentioned that the staff has set up monthly meetings to create an action plan for item #22. Sunny stated that he believes if the results are comparable from current full vs reduced dynamics models, then that would be a good start for the number of model reduction effort. The group discussed the action items. The group did not voice any modifications.
- Agenda Item 2 – Future Modeling Approach:
- Agenda Item 2a – MDWG Group Recommendation for Dispatching by SPP:
  Nate Morris presented the objective of the MDWG Group Recommendation for Dispatch agenda item to the group. Nate mentioned the goal for this agenda item is to get direction from the group on high-level requirements for the MDWG Power Flow Focus Group to consider in developing the details of the MDWG case dispatching by SPP staff. Sunny Raheem mentioned that he would like to get thoughts on if the group is looking for a reliability block or more economical dispatch.

The group discussed different dispatching approaches such as an anticipated market, reliability, or ECDI based dispatches. The group discussed how the different dispatches would work with firm or non-firm transmission service. The group discussed the benefits and challenges of each type of dispatch. The group voiced concerns over limitation of reviewing information in the ECDI and market dispatches. Members of the group voice their opinions about using the legacy BA or SPP footprint BA (“Super BA”) approach for transactions accounting.

The group discussed how retirements would be handled in the dispatching approach. Some members voiced support of SPP dispatching the models if it increased efficiency and is achievable for staff to conduct the work. The group asked the MDWG Power Flow Focus Group to review the current state of MDWG dispatching and the ECDI dispatching. The group also asked for the comparisons to be conducted after the power flow model build is complete.

Action Item: MDWG Power Flow Focus Group to look at MDWG Dispatching Methodology

- Agenda Item 3 – MDWG Manual:
- Agenda Item 3a – Language Approval (Approval Item):
  Michael presented the language approval items that the MDWG manual task force would like to seek. Michael stated that the manual has been renumbered to version 2.0 for the changes and for the new formatting of the manual. The group discussed general clean up items and additions to the manual. Michael mentioned the removal of the responsible entities language in Section 2: General Information due to the addition of Scope of Applicability Section addition.

The group discussed the language in the On-Peak/Off-Peak Models in Section 3: Steady-State Data Requirements. The group redlined the language during the meeting. After a lengthy discussion, the group requested the MDWG manual task force to review the latest presented language for discussion at the December MDWG conference call.

Michael presented the highlighted language in the Area Summary Report Section 3: Steady-State Data Requirements.

Nate opened the floor to entertain a motion.

Motion: Jerad Ethridge motioned to approve the manual changes excluding the On Peak Off Peak items as presented during the meeting (NOV1_MM_Attach3 - 3. SPP Model Development Procedure Manual 2018 v2.0.docx). Reené Miranda seconded the motion. The motion passed unanimously.

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- Agenda Item 4 – 2019 MDWG Build:
- Agenda Item 4a – Power Flow Build Update:
Moses provided a schedule update for Pass 3 and Pass 4. Moses communicated that the lockdown date for data submission is January 11th, 2019. Moses provided an update on the report card. Moses provided an update on EDST. Moses mentioned that staff is working on prioritizing EDST enhancements.

Agenda Item 5 – Break:

Agenda Item 6 – Stakeholder Prioritization Process Overview:
Terry Rhoades presented the Stakeholder Prioritization Process Overview. Terry provided an overview for SPP Stakeholder Portfolio inputs such as projects, revision request, enhancements, and defects. Terry presented in detail the portfolio inputs including, report publishing, stakeholder feedback/questions, quarterly meetings, portfolio adjustments, and updating the posted report. Terry provided an overview of next steps and additional information links to the Stakeholder Prioritization Page.

Agenda Item 7 – MDWG Governing & Guidance Documents:
- Agenda Item 7a – MDWG Charter Revision (Approval Item):
Nate Morris mentioned due to the meeting time constraint that the MDWG Charter Revision will be solicited for motion and voting via email protocol. Nate mentioned the change is based on previous meeting’s discussion around expanding the voting representation of the group. The group did not voice concerns with this approach.

Action Item: Nate and Sunny to initiate email voting for Item 7a (Charter Approval)

Nate and Sunny solicited the membership via email voting protocol entertaining an approval motion for the MDWG Charter Revisions.

Motion: Scott Schichtl motioned to approve the MDWG Charter Revisions (NOV1_MM_Attach4 - 7a. MDWG Charter 20180731_redline.docx). Joe Fultz seconded the motion. The motion passed unanimously.

- Agenda Item 7b – Charter Guidance Revisions:
Tabled for future meeting discussion

Agenda Item 8 – MDWG Focus Group Updates:
Nate Morris asked the Focus Groups leaders if they have any questions or would like to present updates to MDWG for their recent activities. Marcus Moor presented the overview for the MDWG Dynamics Focus Group activities. Marc mentioned the group started its manual review and would like to get education on how SPP performs UFLS. Jerad Ethridge presented the overview for the MDWG Power Flow Focus Group activities. Jerad mentioned that the group has started a list of topics for future meetings including the MDWG dispatch approach and MDWG manual review. Reené Miranda presented the overview for the MDWG Short Circuit Focus Group activities. Reené mentioned the group is discussing short circuit issues pertaining to tier 1 data for short circuit models.

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**Agenda Item 10 – Administrative Items:**
- **Agenda Item 10a – Summary of Action Items:**
  MDWG Power Flow Focus Group to look at MDWG Dispatching Methodology
  Nate and Sunny to initiate email voting for Item 7a (Charter Approval)

- **Agenda Item 10b – Future Meetings:**
  Nate Morris provided a recap of the upcoming future meetings.

- **Agenda Item 10c – Adjourn Meeting:**
  With no further discussion, Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

  **Motion:** Reené Miranda motioned to adjourn the meeting and table the remaining items. Jason Shook seconded it. The motion passed unanimously.

  The meeting adjourned at 12:07PM (CDT).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
9. Administrative Items ............................................................................................. Nate Morris (10 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Conference Call, December 6th 9am – 12pm
         2. Face-to-Face, OKGE in OKC January 8 (8am-5pm) – 9 (8am-12pm)
         3. Discuss Feb 2019 – Jan 2020 monthly calls
      ii. Manual Task Force:
          1. 2nd, 3rd, and 4th Thursday of each month 9am-11am
      iii. Focus Groups Kick Off Meetings:
          1. Power Flow: November 6th (9:00 – 11:00am)
          2. Dynamics: November 14th (9:30 – 11:30am)
          3. Short Circuit: November 27th (9:00 – 11:00am)
   c. Adjourn

Note: The approval items denoted with “**” shall be jointly developed by PC, TP, and MDWG.

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Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
October 4th: 9:00 A.M. – 12:00 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
Sunny Raheem mentioned that Nate Morris (Chairman) would not be available for the meeting. The Chairman appointed Derek Brown (Vice-Chairman) as Chairman for the meeting.

The meeting was called to order at approximately 9:01 a.m. on October 4th. The SPP Antitrust statement was read to the group at the start of the meeting on October 4th.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
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<td>Reené Miranda</td>
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Additional Guests present:

In addition to WebEx attendance

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<td>David Koone, Eddie Watson, Kelsey Allen, Jeff McDiarmid, Michael Odom, Moses Rotich, Shahrokh Akhlaghi, Theva Coleman,</td>
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– **Agenda Item 1e(i) – Agenda Review (Approval Item):**
Derek Brown asked the group if they had any modifications to the agenda or issues with the posted material. The group did not voice any modifications.

Derek opened the floor to entertain a motion.

**Motion:** Jason Shook motioned to approve the agenda as presented during the meeting (OCT4_MM_Attach 1 - 1e. MDWG Meeting Agenda 20181004.docx). Dustin Betz seconded the motion. The motion passed unanimously.

– **Agenda Item 1f(i) – September 6th, 2018 Meeting Minutes Review:**
Derek Brown presented the September 6th meeting minutes. The group discussed the meeting minutes. The group did not voice any modifications.

Derek opened the floor to entertain a motion.

**Motion:** Jerad Ethridge motioned to approve the September 6th, 2018 meeting minutes as presented at the meeting (OCT4_MM_Attach 2 - 1f. MDWG Minutes September 6, 2018.PDF). Alex Mucha seconded the motion. The motion passed unanimously.

– **Agenda Item 1g – Action Items Review:**
Sunny Raheem presented an overview of the current action items in particular action item #24. Sunny mentioned he reached out to the SPP GI staff and they believe the current language in the GIA can enforce the requirement to use standard library models in the GI process.
- **Agenda Item 2 – 2018 ITPNT Lessons Learned:**
Eddie Watson presented the 2018 ITPNT lessons learned. Eddie provided an overview of 2018 ITPNT issues impacting SPP work activities and schedule, lessons learned, and best practices and planned enhancements. Eddie presented the detailed issues encountered during the model build. Additionally, Eddie presented staff proposed improvements including:

- SPP Internal Model Validation Task Force
- Build in additional quality review time in the model development schedule
- Continual work towards reducing number of models.
- Leverage expertise from MDWG Focus Groups for additional staff and member training
- Continual Improvement of documentation processes and communication

- **Agenda Item 3 – Power Flow, Dynamics, Short Circuit Focus Group Update:**
Sunny Raheem provided a brief update on the status of the Power Flow, Dynamics, and Short Circuit Focus Groups. Sunny mentioned that Staff met with the Leaders of the groups last week and have recently scheduled the first kick off meetings for next week. Derek Brown and Sunny Raheem thanked the focus group participants and leaders.

- **Agenda Item 4 – 2020 ITP Generation and Load Review:**
Theva Coleman presented the 2020 ITP Generation and Load Review topic. Theva mentioned the objective of the gen and load review is to acquire an accurate representation of load forecasts and existing generation within and outside of the SPP footprint. Theva outlined the steps for acquiring data, project timeline, and stakeholder data coordination. Theva mentioned the upcoming milestones including the next pass for review from October 15th to October 26th.

**Agenda Item 5 – MDWG Membership Update:**
Derek Brown started the MDWG Membership Updates discussion. Derek asked Sunny Raheem to provide an update on the MDWG Membership.

Sunny presented the results for the Chair nomination. Sunny mentioned that he received several nominations from the group for Nate Morris to continue as Chair and no other candidates were provided during the solicitation period. Sunny mentioned he has discussed the results with Nate and received confirmation that Nate would like to continue as Chair.

Sunny mentioned that Gimod Olapurayil has left ITC Great Plains and Wayne Haidle has retired from Basin Electric Power Cooperative, thus resulting in two open voting seats. Sunny asked the group for their thoughts on the best approach for soliciting the open seats as discussion around the MDWG Charter and voting seats are currently occurring and are on the agenda for today’s meeting. The group provided some suggestions but majority decided to move to the next agenda topic before making a group recommendation.
Agenda Item 6 – MDWG Charter Guidance Revisions:
Derek Brown led the MDWG Charter Guidance Revision. The group discussed the current redlines and number of voting seats. The group redlined the document on the conference call. The group agreed to mirror the TWG requirement to have up to 24 members.

Action Item: Sunny will send out the working document to the group in particular Marc Moor and Jason Shook for further updating to be presented as an approval item at the November MDWG conference call.

Action Item: Sunny will solicit for those interested in Membership for the two open seats ahead of the next MDWG conference call.

Agenda Item 7 – MDWG Dynamics Full vs Reduced Case Benchmarking:
Sunny Raheem led the discussion for MDWG Dynamics Full vs Reduce Case Benchmarking. Sunny mentioned the effort is proposing to remove the full cases and only build reduced cases. Sunny explained that third tier entities and beyond are the equivalenced areas in the reduced cases. Some members mentioned they only use the reduced cases. OKGE wanted to follow up with their dynamics SMEs to check if they used the full cases.

Action Item: SPP Staff will solicit members to send in 3-5 worse events to benchmark against. Staff plans to bring the results to the December MDWG meeting seeking approval based on results.

Agenda Item 8 – 2019 MDWG Build:
- Agenda Item 8a – Power Flow Build Update:
Moses Rotich provided an update for the 2019 MDWG power flow build. Moses emphasized for folks to check DocuCheck every pass to mitigate recurring issues and to submit load and generation data as soon as possible. Moses mentioned the result of not fixing DocuCheck issues.

Moses mentioned the report cards would be going to TWG up to MOPC highlighting folks who wait too long or did not submit data by deadlines.

Moses provided an update for MMWG power flow and MOD activities. Moses said MMWG is moving to PSS/E Version 34.4 or higher for the 2019 MMWG Build. He also mentioned that SPP is planning to upgrade to MOD v10 for the 2020 MDWG build.

- Agenda Item 8b – Dynamics Model Schedule (Approval Item*):
Sunny Raheem started the Dynamics Model Build Schedule discussion. Sunny mentioned that SPP has a new team member, Shahrokh Akhlaghi, join recently. Sunny mentioned Shahrokh will be assisting in the 2019 MDWG dynamics build. Sunny presented two 2019 MDWG schedule options for the group. The group decided to table schedule approval until the dynamic full vs reduce case benchmarking is completed.
Agenda Item 9 – Break:

Agenda Item 10 – MDWG Manual:
- Agenda Item 10a – Language Approval (Approval Item):
  Michael Odom presented the most recent language edits to the group. Michael outlined the wholesale changes for changing out workbook references for EDST. Michael presented the dynamic data format language developed by the MDWG manual task force.

Derek Brown opened the floor to entertain a motion.

Motion: Jerad Ethridge motioned to approve the EDST and dynamic data format language updates as presented at the meeting (OCT4_MM_Attach 2 - 10. SPP Model Development Procedure Manual 2018 v1.2_Pending.docx). Jason Shook seconded the motion. The motion passed unanimously.

The group decided to continue discussing the dynamic data list pertaining to user written models. In addition, the group will review the on-peak/off-peak model revisions sections at the next November meeting.

- Agenda Item 10b – MOD 26 & 27 / Acceptable Model Discussion:
  The group discussed this item under Agenda Item 10a.

Agenda Item 11 – Future Modeling Approach:
- Agenda Item 11a – MDWG Group Recommendation for Dispatch by SPP:
  Agenda item tabled until the next meeting.

- Agenda Item 10b – Future Meetings:
  Derek Brown provided a recap of the upcoming future meetings.

- Agenda Item 10c – Adjourn Meeting:
  With no further discussion, Derek Brown solicited a motion to adjourn the meeting and table the remaining items.

Motion: Reené Miranda motioned to adjourn the meeting and table the remaining items. Jason Shook seconded it. The motion passed unanimously.

The meeting adjourned at 11:59AM (CDT).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
October 4, 2018
Net Conference
• AGENDA •
9:00 a.m. – 12:00 p.m. (CDT)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. September 6th, 2018 (Approval Item)
   g. Action Items Review
2. 2018 ITPNT Lessons Learned.......................................................Eddie Watson (25 mins)
3. Power Flow, Dynamics, Short Circuit Focus Group Update..............Sunny Raheem (5 mins)
4. 2020 ITP Generation and Load Review ........................................Theva Coleman (10 mins)
5. MDWG Membership Update ..........................................................All (10 mins)
6. MDWG Charter Guidance Revisions .............................................All (20 mins)
7. MDWG Dynamics Full vs Reduced Case Benchmarking ..................All (15 mins)
8. 2019 MDWG Build
   a. Power Flow Build Update ......................................................Moses Rotich (5 mins)
   b. Dynamics Model Schedule (Approval Item*) ..........................Sunny Raheem (15 mins)
9. Break ..................................................................................................(10 mins)
10. MDWG Manual
    a. Language Approval (Approval Item*) ......................................Michael Odom (20 mins)
    b. MOD 26 & 27 / Acceptable Model Discussion............................All (15 mins)
11. Future Modeling Approach
    a. MDWG Group Recommendation for Dispatch by SPP .................All (15 mins)

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12. Administrative Items .............................................................................................................. Nate Morris (5 mins)
   a. Summary of Action Items
   b. Future Meetings (Central Time)
      i. MDWG
         1. Conference Call, November 1st 9am – 12pm
         2. Conference Call, December 6th 9am – 12pm
         3. Face-to-Face, OKGE in OKC January 8 (8am-5pm) – 9 (8am-12pm)
      ii. Manual Task Force:
         1. 2nd, 3rd, and 4th Thursday of each month 9am-11am
      iii. Focus Groups Kick Off Meetings:
         1. Power Flow: October TBD
         2. Dynamics: October TBD
         3. Short Circuit: October TBD
   c. Adjourn

Note: The approval items denoted with "**" shall be jointly developed by PC, TP, and MDWG.

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Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
September 6th: 9:00 A.M. – 12:00 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
Sunny Raheem mentioned that Nate Morris (Chairman) and Derek Brown (Vice-Chairman) will not be available for the first hour of the meeting. The Chairman has appointed Scott Schichtl as Proxy Chairman for the first hour of the meeting.

The meeting was called to order at approximately 9:02 a.m. on September 6th. The SPP Antitrust statement was read to the group at the start of the meeting on September 6th.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

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– **Agenda Item 1e(i) – Agenda Review (Action Item):**
Proxy Chairman, Scott Schichtl, asked the group if they had any modifications to the agenda or issues with the posted material. The group did not voice any modifications.

Scott opened the floor to entertain a motion.

**Motion:** Jason Shook motioned to approve the agenda as presented during the meeting (SEP6_MM_Attach 1 - 1e. MDWG Meeting Agenda 20180906.docx). Dustin Betz seconded the motion. The motion passed unanimously.

– **Agenda Item 1f(i) – August 2nd, 2018 Meeting Minutes Review:**
Scott Schichtl and Sunny Raheem presented the August 2nd meeting minutes. The group discussed the meeting minutes. The group did not voice any modifications.

Scott opened the floor to entertain a motion.

**Motion:** Dustin Betz motioned to approve the August 2nd, 2018 meeting minutes as presented at the meeting (SEP6_MM_Attach 3 - 1f. MDWG Minutes August 2, 2018.PDF). Alex Mucha seconded the motion. The motion passed unanimously.

– **Agenda Item 1g – Action Items Review:**
Sunny Raheem presented an overview of the current action items and status. Sunny gave an update for action item #22, model reduction and year 1 review. Sunny mentioned that staff would send out a survey for external model needs. Sunny asked the group if anyone had questions about a particular action item or status. The group did not voice any questions.
Agenda Item 2 – MDWG Manual:
- Agenda Item 2a – Language Approval (Approval Item):

Michael Odom led the discussion for the MDWG Manual language approval. Michael presented the changes to the Revision History and Section 1: Introduction. Marcus Moor, Reené Miranda, and Michael Odom provided their thoughts on the need for the new language in Section 1. They communicated the importance of clearly stating the primary deliverable for the SPP MDWG models.

Scott opened the floor to entertain a motion.

Motion: Jason Shook motioned to approve the Section 1 changes contained within the procedure manual as posted and presented (SEP6_MM_Attach 3 - 2. SPP Model Development Procedure Manual 2018 v1.2_Pending_09062018.docx). John Boshears seconded the motion. The motion passed unanimously.

Michael mentioned the MDWG Manual was updated for wholesale changes for replacing the workbook references to EDST.

Nate Morris joined the conference call and resumed Chair responsibilities from Scott Schichtl. Nate thanked Scott for facilitating and chairing the meeting in his absence. The group discussed agenda item 2b prior to the remaining items under agenda item 2a.

Michael presented the updated language for the MDWG renewable dispatch methodology. Michael communicated the need for the new language due to the current state of flux for the renewable dispatch methodology. Moses Rotich asked the group for guidance on renewable dispatch methodology for the current model build.

Nate mentioned some of the percentage values in the renewable dispatch methodology proposed language could be viewed as questionable. Michael explained the reasoning behind the varying percentage numbers.

Moses asked if the group would like to consider the last bullet point item for this year’s model build. Nate asked the group on their thoughts on the language for the current year’s model build. The group communicated their thoughts. Sunny Raheem suggested taking a break so Staff could redline the language based on the group feedback. Nate agreed to the break suggestions and requested the group be back in 10 minutes. Staff and Chris Colson redlined the language and presented it after the break. The group did not voice any concerns over the proposed redline language.

Nate opened the floor to entertain a motion.

Motion: Reené Miranda motioned to approve the renewable dispatch language within the procedure manual as presented to suffice for this model build (2019 MDWG) and requested the MDWG Manual Task Force review the language for future model builds (SEP6_MM_Attach 3 - 2. SPP Model Development Procedure Manual 2018 v1.2_Pending_09062018.docx). Holli Krizek seconded the motion. The motion passed unanimously.
Agenda Item 2b – MOD 26 & 27 / Acceptable Model Discussion:
Michael presented the language proposed under the Dynamic Data Format Section of the MDWG Manual. Michael mentioned that the user models do increase troubleshooting time and sometimes have missing information. The group provided their thoughts about the effort for standard models. Marcus Moor provided his thoughts and proposed language changes. The group discussed the proposed language. The group discussed adding requirements to the SPP Generator Interconnection Agreement (GIA).

Andy Berg asked if the Generator Owner (GO) will have to redo MOD 26 & 27 standard testing or if they will be required to verify that the standard model response is acceptable in comparison to the existing MOD 26 & 27 verification testing. The group discussed the MOD 26 & 27 verification questions proposed and if language will be required. The group asked if the language would apply to Bulk Electric System (BES) generators or non-BES generators. The group requested staff to take the following action items for next steps in the standard model effort.

AL: Take updated Dynamic Data Format Section language back to the MDWG Manual Task Force for additional discussion. MDWG Manual Task Force should discuss the need for clarification applicability to non-BES and BES facilities in this section. Task Force should consider discussing a retroactive timeframe for existing facilities.

AL: Staff to coordinate with SPP GI for feedback on including standard library models language in the GIA.
**Agenda Item 3 – Power Flow, Dynamics, Short Circuit Focus Group Discussion:**
Sunny Raheem presented the scope and structure of the focus groups. Sunny re-iterated the benefit of the focus groups to the group. Sunny asked the group if they had any questions about the scope and structure as presented. The group did not voice any concerns.

Nate and Sunny thanked participants and leaders for volunteering. Dustin Betz communicated he is interested in joining a focus group and others at NPPD might be interested in them as well. Nate suggested to Dustin to send Sunny a note about the joining the focus groups.

Sunny mentioned the goal is to kick off the focus groups in October. Sunny will coordinate with the Leaders of the groups and then reach out to the participants.

**Agenda Item 4 – Break:**
The group took their break during the discussion of Agenda Item 2a renewable dispatch.

**Agenda Item 5 – MDWG Charter Revisions:**
Nate Morris led the discussion for the MDWG Charter revisions and framework document. Sunny presented the redline document received so far with the groups’ changes. The group discussed the redline changes in particular the probationary timeframe requirements, transfer of voting rights, make of a balanced representation, and number of voting members. Sunny mentioned the feedback from SPP management for a balanced group representation. The group discussed the balance and number of voting members at great length.

**Agenda Item 6 – 2018 MDWG Dynamics Model Build Update:**
Tabled for future meeting

**Agenda Item 7 – 2019 MDWG Build:**
- **Agenda Item 7a – Power Flow Build Update:**
  Tabled for future meeting

- **Agenda Item 7b – Dynamics Model Schedule (Approval Item):**
  Tabled for future meeting

**Agenda Item 8 – Future Modeling Approach:**
- **Agenda Item 8a – MDWG Dispatch by SPP:**
  Tabled for future meeting

**Agenda Item 9 – 2020 ITP Generation and Load Review:**
Tabled for future meeting

**Agenda Item 10 – Administrative Items:**
- **Agenda Item 10a – Summary of Action Items:**
  - Take updated Dynamic Data Format Section language back to the MDWG Manual Task Force for additional discussion
  - Staff to coordinate with SPP GI for feedback on including standard library models language in the GIA.
- **Agenda Item 10b – Future Meetings:**
  Nate Morris provided a recap of the upcoming future meetings.

- **Agenda Item 10c – Adjourn Meeting:**
  With no further discussion, Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

  **Motion:** Jerad Ethridge motioned to adjourn the meeting and table the remaining items. Jason Shook seconded it. The motion passed unanimously.

The meeting adjourned at 12:27PM (CDT).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
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Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
September 6, 2018
Net Conference

• A G E N D A •
9:00 a.m. – 12:00 p.m. (CDT)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. August 2nd, 2018 (Approval Item)
   g. Action Items Review
2. MDWG Manual
   a. Language Approval (Approval Item*) ........................................ Michael Odom (25 mins)
   b. MOD 26 & 27 / Acceptable Model Discussion.......................................................... All (20 mins)
3. Power Flow, Dynamics, Short Circuit Focus Group Discussion .................................... All (30 mins)
4. Break ...................................................................................... (10 mins)
5. MDWG Charter Revision ............................................................. All (20 mins)
6. 2018 MDWG Dynamics Model Build Update .................................. Sunny Raheem (5 mins)
7. 2019 MDWG Build
   a. Power Flow Build Update ......................................................... Moses Rotich (5 mins)
   b. Dynamics Model Schedule (Approval Item*) ................................. Sunny Raheem (20 mins)
8. Future Modeling Approach
   a. MDWG Dispatch by SPP .......................................................... All (15 mins)
9. 2020 ITP Generation and Load Review ........................................ Theva Coleman (10 mins)
10. Administrative Items ................................................................. Nate Morris (10 mins)
    a. Summary of Action Items
    b. Future Meetings
       i. October 4th
    c. Adjourn

Note: The approval items denoted with "*" shall be jointly developed by PC, TP, and MDWG.
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
August 2nd: 10:00 A.M. – 1200 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 10:01 a.m. on August 2nd. The SPP Antitrust statement was read to the group at the start of the meeting on August 2nd.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

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<thead>
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<th>Proxy</th>
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<td>Dustin Betz</td>
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<td>Oklahoma Gas &amp; Electric</td>
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<td>Joe Fultz</td>
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<td>Grand River Dam Authority</td>
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<td>Holli Krizek</td>
<td>NO</td>
<td>Chris Colson</td>
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<td>Reené Miranda</td>
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<tr>
<td>Sunny Raheem</td>
<td>YES</td>
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<td>Southwest Power Pool, Inc.</td>
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**Additional Guests present:**

**In addition to WebEx attendance**

<table>
<thead>
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<th>Guests</th>
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<tr>
<td>Martin Green</td>
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<td>Evergy Companies</td>
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<td>James Ging</td>
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<td>Alan Burbach</td>
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<td>Armin Sehic, Bruce Doll</td>
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<td>Mark Mallard</td>
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<td>Jason Lawter</td>
<td>Oklahoma Corporation Commission</td>
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<td>Daryl Huslig</td>
<td>Oklahoma Electric and Gas Company</td>
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<td>John Mayhan</td>
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<td>Eddie Watson, Kim Farris, Moses Rotich</td>
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<td>Aravind Chellappa, Frank Favela</td>
<td>Southwestern Public Service</td>
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<td>Tanner New</td>
<td>Sunflower Electric Power Cooperative</td>
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<tr>
<td>Brianna Haug, Chris Colson, Garrick Nelson, Josie Daggett</td>
<td>Western Area Power Administration</td>
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– Agenda Item 1e(i) – Agenda Review (Action Item):  
Nate Morris asked the group if they had any modifications to the agenda or issues with the posted material. The group did not voice any modifications.

Nate opened the floor to entertain a motion.

Motion: Chris Colson motioned to approve the agenda as presented during the meeting (AUG2_MM_Attach 1 - 1e. MDWG Meeting Agenda 20180802.docx). Scott Schichtl seconded the motion. The motion passed unanimously.

– Agenda Item 1f(i) – July 12th, 2018 Meeting Minutes Review (Action Item):  
Nate Morris and Sunny Raheem presented the July 12th meeting minutes. The group discussed the meeting minutes. Nate mentioned the recommendation by a group member to post the previous meeting minutes and supplemental data in one file. Staff will attempt to post meeting material and support files as one file in the subsequent meeting background material.

Nate opened the floor to entertain a motion.

Motion: John Boshears motioned to approve the July 12th, 2018 meeting minutes as presented at the meeting (AUG2_MM_Attach 2 - 1f. MDWG Minutes July 12, 2018_redline.docx). Derek Brown seconded the motion. The motion passed with one abstention. Reené Miranda mentioned that he abstained because he was not present at the July 12th meeting.

– Agenda Item 1g – Action Items Review:  
Sunny Raheem presented an overview of the current action items and status. Sunny asked the group if anyone had questions about a particular action item or status. The group did not voice any questions.
Agenda Item 2 – MDWG Manual:
- Agenda Item 2a – SPP Legal Model Release Language Addition:
Sunny Raheem presented the SPP Legal requested Model Release Language addition and removal of outdated language. Sunny mentioned the new language aligns with the model release language on the SPP corporate website. The group did not voice any concerns or questions about the model release language.

- Agenda Item 2b – Language Approval (Approval Item):
Nate Morris led the group in the language approval discussion. Chris Colson asked Nate if he would be open to entertaining a motion.

Nate opened the floor to entertain a motion.

Motion: Chris Colson motioned to approve all changes contained within the procedure manual posted and presented (AUG2_MM_Attach 3 - 2. SPP Model Development Procedure Manual 2018 v1_pending updates_Revised_12JUL18.docx). Alex Mucha seconded the motion.

During the discussion of the motion, Reené Miranda requested a quick glance through the changes for the group to review. The group discussed dispatching renewables with firm and non-firm service. The group compared the proposed MDWG language against the ITP language. The group discussed concerns related to stability issues because of the new wind and solar generation amounts. The group discussed how replacement data is incorporated in calculation when required. The group asked staff if the renewable dispatch would be available for the current 2019 MDWG build. Moses Rotich responded that SPP would provide the dispatch in spreadsheet format. Replacement data will be used for wind farms that do not have any historical data or have only a few years of historical data.

The motion passed with one abstention. Dustin Betz mentioned he abstained because he was not available to join the call for the full discussion.

Chris Colson and the group thanked Michael Odom for his efforts in reformatting the manual and for keeping the task force on track.
- **Agenda Item 2c – Power Flow, Dynamics, Short Circuit Task Force Discussion:**
  Nate Morris led the group in the three task force discussion. Nate mentioned his thoughts on the structure of the focus groups, participation, and deliverables. Sunny Raheem mentioned staff’s suggestions on keeping the groups informal at least to start with. Sunny mentioned that staff would be assigned to help support the focus groups. Sunny mentioned that he thinks the benefit will be mutual for members and staff for educational purposes. Eddie Watson mentioned that he would like the focus groups to be an avenue for both staff and members to learn from each other.

  Chris Colson expressed strong support for this effort. Chris stated WAPA expressed the need to form these three groups as part of the MDWG charter. Chris mentioned that the focus groups should not be composed of only model builders but should also include end users of the models who can discuss some of the issues that they are seeing.

  As next steps, Sunny recommended that entities volunteer for these different groups ahead of the September meeting. Nate also commented that Data Submitters who are not familiar with certain aspects such as dynamics should get involved in them to learn.

  **Action Item: Staff to poll conference call participates and MDWG exploder email lists for volunteers.**

- **Agenda Item 3 – MDWG Charter Revisions:**
  Nate Morris led the group in the MDWG Charter Revision discussion. Nate asked Sunny Raheem to present the draft provided to staff. Sunny presented the draft revisions. Sunny mentioned staff will have a preliminary review of proposed language before the September meeting.

  Jason Shook disagreed with some of the proposed language. Jason mentioned that membership should be open to any SPP member regardless of registration. Jason did not think it is appropriate to limit SPP members. Jason mentioned entities such as GOs, DPs, and any entity with vested interest in the models should have a stake in the models.

  Nate answered that every entity can still contribute to the group without being a voting member. Jason responded that this criteria can apply to Transmission Planning entities also; Transmission Planners can actively participate without being members. Dustin Betz stated he liked the idea of expanding to accommodate other members but had concerns about the prescriptive nature of the language.

  **Action Item: Staff to send the proposed language along with the current MDWG charter to Data Submitters for comments on membership guidelines in the charter revision.**

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Agenda Item 4 – MOD 26 & 27 Model Validation:
- Agenda Item 4a – Standard Model List:
Joe Fultz led the group in the Standard Model List discussion. Joe mentioned that SPP had sent guidelines a while back. Joe mentioned his view was that there were several ways to validate the data. Sunny Raheem provided a discussion summary that staff had with MISO and how MISO moved to a standard model list. Chris Colson suggested that some language be drafted in the manual that states that SPP adopts the NERC standard models and that Generator Owners use these models in their testing. Nate Morris agreed with Chris. Chris noted that there is a gap with GOs who do not have TPs. Reené Miranda mentioned that SPP could reach out to ERCOT to find out how their standard model list process worked. Derek Brown agreed with adopting the standard models in the manual but noted that a few exceptions may have to be made for GOs who have already provided their MOD-026 & 027 data.

Action Item: MDWG Manual Task Force to start discussing and drafting standard model approach with consideration of exceptions.

Agenda Item 5 – 2019 MDWG Power Flow Model Build Discussion:
- Agenda Item 5a – Power Flow Build Update:
Moses Rotich provided an update for the 2019 MDWG Power Flow Model build. Moses mentioned the status of the model build. Moses asked the group if they had any questions or concerns about the model build. The group did not voice concerns.

- Agenda Item 5b – Automation Improvements:
Sunny Raheem provided an overview of recent automation efforts. Sunny mentioned Zack Bearden identified a need for internal automation. This automation also meets some of the suggestions from the MDWG untimely data submission survey. Sunny asked if the group had any suggestions or comments about the automation that is under development for load pattern review. The group did not voice any questions or concerns.
Agenda Item 6 – Future Modeling Approach:
- Agenda Item 6a – ITP to MMWG Conversion:
  Tabled for future meeting

- Agenda Item 6b – MDWG Models Dispatched by SPP:
  Tabled for future meeting

Agenda Item 7 – 2019 MDWG Dynamics Model Draft Schedule:
Sunny Raheem presented the first draft of the 2019 MDWG dynamic model build schedule. Sunny explained the internal SPP TPL need for finalizing models in December. Sunny mentioned it would be a good time for the members to communicate their compliance year requirements since the proposed schedule has a December finalization date. Several members voiced their concerns about the December model finalization date due to their compliance year being January to December.

Agenda Item 8 – Administrative Items:
- Agenda Item 8a – Summary of Action Items:
  • Staff to poll conference call participates and MDWG exploder email lists for volunteers.
  • Staff to send the proposed language along with the current MDWG charter to Data Submitters for comments on membership guidelines in the charter revision.
  • MDWG Manual Task Force to start discussing and drafting standard model approach with consideration of exceptions.

- Agenda Item 8b – Future Meetings:
  Nate Morris provided a recap of the upcoming future meetings. Nate requested the September 6th meeting be 3 hours in duration to allow adequate time for tabled discussions.

- Agenda Item 8c – Adjourn Meeting:
  With no further discussion, Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

  Motion: Chris Colson motioned to adjourn the meeting. Chris Colson seconded it. The motion passed unanimously.

  The meeting adjourned at 12:15PM (CDT).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
August 2, 2018
Net Conference
• A G E N D A •
10:00 a.m. – 12:00 p.m. (CDT)

1. Administrative Items ................................................................................................ Nate Morris (5 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. July 12th, 2018 (Approval Item)
   g. Action Items Review
2. MDWG Manual
   a. SPP Legal Model Release Language Addition ......................... Sunny Raheem (5 mins)
   b. Language Approval (Approval Item) ........................................ All (15 mins)
   c. Power Flow, Dynamics, Short Circuit Task Force Discussion ............ All (20 mins)
3. MDWG Charter Revision ...................................................................................... All (15 mins)
4. MOD 26 & 27 Model Validation Discussion
   a. Standard Model List................................................................. Joe Fultz/All(15 mins)
5. 2019 MDWG Power Flow Build
   a. Power Flow Build Update ..................................................... Moses Rotich/All (5 mins)
   b. Automation Improvements ................................................... Zack Bearden (5 mins)
6. Future Modeling Approach
   a. ITP to MMWG Conversion....................................................... All (15 mins)
   b. MDWG Models dispatched by SPP .......................................... All (10 mins)
7. 2019 MDWG Dynamics Model Draft Schedule ............................................ All (5 mins)
8. Administrative Items .................................................................................. Nate Morris (5 mins)
   a. Summary of Action Items
   b. Future Meetings
      i. September 6th
   c. Adjourn

Note: The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG.

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Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
July 12th: 1:00 P.M. – 3:00 P.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 1:00 p.m. on July 12. The SPP Antitrust statement was read to the group at the start of the meeting on July 12.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

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<thead>
<tr>
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</tbody>
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Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
### Additional Guests present:

**In addition to WebEx attendance**

<table>
<thead>
<tr>
<th>Guests</th>
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<tbody>
<tr>
<td>Martin Green, Scott Rainbolt</td>
<td>American Electric Power</td>
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<tr>
<td>David Vernier</td>
<td>Associated Electric Cooperative Inc.</td>
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<tr>
<td>Jerry Bradshaw</td>
<td>City Utilities of Springfield</td>
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<tr>
<td>Jordan Lamb</td>
<td>East River Cooperative</td>
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<tr>
<td>Sonny Patel</td>
<td>EDF-RE</td>
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<tr>
<td>Jeff Crites</td>
<td>Empire District Electric</td>
</tr>
<tr>
<td>Lafayette Gatewood IV, Jeremy Harris, Ryan Baysinger, Marcus Moor, Pallab Datta</td>
<td>Evergy Companies</td>
</tr>
</tbody>
</table>
– **Agenda Item 1e(i) – Agenda Review (Action Item):**
Nate Morris asked the group if they had any modifications to the agenda or issues with the posted material. Sunny Raheem mentioned that staff would like to request adding 2019 MDWG Power Flow Model Build Discussion to the agenda. The group decided to place the 2019 MDWG Power Flow Model Build Discussion as agenda item #5.

Nate opened the floor to entertain a motion.

**Motion:** Derek Brown motioned to approve the agenda as presented during the meeting *(Jul12_MM_Attachment 1 - 1e. MDWG Meeting Agenda 20180712_redline.docx).* Jerad Ethridge seconded the motion. The motion passed unanimously.

– **Agenda Item 1f(i) – June 28th, 2018 Meeting Minutes Review (Action Item):**
Nate Morris and Sunny Raheem presented the June 28 meeting minutes with latest member provided redlines. The group discussed the meeting minutes. Aravind Chellappa mentioned he had limited time to review the background material and previous meeting minutes since he had other obligations during majority of the review period. Derek Brown requested KCPL and Westar be presented as one entity in the meeting material going forward. Sunny Raheem redlined the June 28, 2018 meeting minutes referencing Evergy for both KCPL and Westar.

Nate opened the floor to entertain a motion.

**Motion:** Derek Brown motioned to approve the June 28th, 2018 meeting minutes as edited and presented at the meeting *(Jul12_MM_Attachment 2 - 1f. MDWG Minutes June 28, 2018_redline.docx).* Gimod Olapurayil seconded the motion. The motion passed with one abstention from Alex Mucha. Alex explained he is abstaining because he was not present at the last meeting.

– **Agenda Item 1g – Action Items Review:**
Sunny Raheem presented an overview of the current action items and status. Aravind Chellappa requested an open-ended action item be added to the list for model reduction and year 1 definition as discussed in the previous meetings.

**Action Item:** Staff to provide updates on the model reduction and Year 1 definition effort as they progress with the action item.

– **Agenda Item 1h – Draft July 12th Agenda:**
Nate Morris asked Sunny Raheem to provide the overview for the August 2nd draft agenda. Sunny presented the August 2nd draft agenda. The group did not mention any concerns or edits to the draft agenda as presented.
Agenda Item 2 – MDWG Manual:
- Agenda Item 2a – Language Approval (Approval Item):
  Michael Odom presented to the group the MDWG manual changes.

In the Bus Section, the group discussed the need for adding an example, consideration of historical consistencies, bus name dependencies in other software such as ASPEN, and purpose of the bus naming conventions.

Holli Krizek mentioned the need to keep the historical consistency language for entities that previously were in the MRO since their naming convention was different. Dustin Betz also mentioned the same concerns. Staff mentioned MMWG requires unique bus names. Zack Bearden mentioned the SPP EMS modeling group uses the bus names. The group discussed setting an effective date for the possible bus naming convention requirements. Eddie Watson mentioned when SPP Operations went through a similar effort they set an effective date for all entities to meet the bus naming convention requirements.

After a lengthy discussion, the group requested the manual task force to review the Bus Section language for reconsideration of the concerns raised at the meeting.

In the Short Circuit Data Format Section, the group discussed the language additions to account for GSU modeling updates for retired generator in short circuit models. The group discussed if the GSUs should be kept online even with a disconnect switch or interruption device. The group provided edits to the manual language.

Nate opened the floor to entertain a motion.

Motion: Jerad Ethridge motioned to approve the language pertaining to pseudo tied loads and short circuit section GSUs language ([Jul12_MM_Attachment 3 - 2a. SPP Model Development Procedure Manual 2018 v1_Revised_12JUL18.docx]). Alex Mucha seconded the motion. The vote discussion lead to additional language to clarify the transformer status. Jerad Ethridge motioned to amend the open motion to account for additional transformer status language. Alex Mucha seconded the motion. The motion passed unanimously.
- Agenda Item 2b – Power Flow, Dynamics, Short Circuit Task Force Discussion:
  Tabled for future meeting.

Agenda Item 3 – MDWG Charter Membership Revisions:
  Tabled for future meeting.

Agenda Item 4 – 2018 MDWG Dynamics Model Build Update:
Michael Odom provided an update on the schedule. Michael reviewed the most recent 2018 Dynamics Model Build schedule. Michael mentioned a consultant has been hired to help mitigate the schedule delay.

Agenda Item 5 – 2019 MDWG Power Flow Model Build Discussion:
Moses Rotich provided an update for the 2019 MDWG Power Flow Model build. Moses mentioned he would create two sets of device control profiles for ITP and MDWG based on member feedback from the previous model build. Moses asked the group if that approach was still the preference. The group agreed to this approach.

To make the members aware, Moses also commented that going forward, the ITP BR models which will be used for TPL and other compliance studies, will be finalized late November/December annually. He noted that members who rely on these models to perform their TPL assessments might want to do a transition in order to align with the release of the models.

Sunny Raheem mentioned resource changes in the modeling group. Sunny mentioned Mitch Jackson accepted a position in Engineering Support and Hagen Boehmer joined the modeling group. Nate Morris asked when the resource changes were effective. Eddie Watson mentioned they are already effective. The group welcome Hagen and thanked Mitch for his service to the group, model builds, and EDST.

Agenda Item 6 – MOD 26 & 27 Model Validation Discussion:
- Agenda Item 6a – Standard Model List:
  Tabled for future meeting

Agenda Item 7 – Engineering Data Submission Tool (EDST):
- Agenda Item 7a – Status Update:
- Agenda Item 7b – Prioritizing Project Enhancements:
  Tabled for future meeting

Agenda Item 8 – Administrative Items:
- Agenda Item 8a – Summary of Action Items:
  • Model reduction and Year 1 definition effort action item updates

- Agenda Item 8b – Future Meetings:
  Nate Morris provided a recap of the upcoming future meetings. Nate mentioned the upcoming MOD training on July 26th and the next MDWG meeting on August 2nd.
- Agenda Item 8c – Adjourn Meeting:
With no further discussion, Nate Morris solicited a motion to adjourn the meeting and table the remaining items.

Motion: Joe Fultz motioned to adjourn the meeting and table the remaining items. Jerad Ethridge seconded it. The motion passed unanimously.

The meeting adjourned at 3:06PM (CDT).

Respectfully submitted,
Sunny Raheem
SPP Staff Secretary
## Revision History

<table>
<thead>
<tr>
<th>Date or Version Number</th>
<th>Author</th>
<th>Change Description</th>
<th>Comments</th>
</tr>
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<tr>
<td>21JUN18</td>
<td>SPP Engineering Modeling</td>
<td>Updated format</td>
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, data owners, equipment, and data submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator's planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC's Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1), and the provisions of the SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;

\(^1\) The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.

\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.
Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.
- Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.
- Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.
- Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.
- Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.
- Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.
- Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

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3 For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
**Applicable Equipment**

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise,

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5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Equivalencing is a general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.
8 Sixth Revised Volume No.1, Attachment AI, Part II-1.
9 Sixth Revised Volume No.1, Attachment AI, Part II-2.
10 Sixth Revised Volume No.1, Part III-30.
11 Sixth Revised Volume No.1, Part III-31.
consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted. Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes.** In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
**General Data Reporting Responsibilities**

The SPP data reporting entities are responsible for the following categories of system modeling data:

1. Steady-State
2. Short Circuit
3. Dynamics

Steady-State models are developed for an annual series of SPP cases, including an annual series of ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by SPP Regional Tariff and Planning Criteria.

Short Circuit models are developed annually using a subset of the Reliability Steady-State models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

The Dynamics Model is also updated annually with current generator unit information. Steady-State models are used in conjunction with dynamic data to run dynamic simulation.

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.
Entities in the SPP Planning Coordinator region that are not members of the SPP but required to submit data (i.e. IPPs, Municipalities) will submit data directly to the Transmission Owner or Balancing Authority in which their system resides. Upon review (i.e. data accuracy, quality) by the Transmission Owner or Balancing Authority the data will then be provided to the SPP during the annual MDWG case type update process. The data submitted will be in the standard PTI format as specified in the MDWG Model Development procedure manual. All non-SPP members that are responsible for submitting this data should directly coordinate with the Transmission Owner or Balancing Authority on timing for sending data, as well as any special requirements in data formatting.

In an effort to determine who is collecting/submitting data for whom, all NERC registered entities within the SPP PC footprint (MOD-032-1: applicable to BA, GO, LSE, RP, TO, TP, and TSP) shall fill out the data coordination workbook to notify SPP if data is being submitted directly to SPP or through some other entity(ies) on behalf of your company. Likewise, SPP shall be notified if your company is submitting data on behalf of another entity(ies).

Confidentiality and Proprietorship

The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

Schedule

As with all schedules, the meeting of deadlines is most critical. All system representatives must familiarize themselves with the schedule well in advance of all deadlines. This will alleviate any problems with the timing of data submittal and data reviews. The schedule for model development will be sent with the first data request as well as posted on the SPP corporate website, www.spp.org.

Steady-State and Short Circuit Model Development

The MDWG Steady-State and Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Data Submittal Workbook. MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the Data Submittal Workbook which is identified in the data preparation section of this manual.

SPP MDWG Steady-State and Short Circuit Models are published according to the approved schedule.

AC Contingency Analysis

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set.
The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.

**Dynamic Model Development**

**Introduction**
The MDWG Dynamic Models include full MMWG cases and machine reduced cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model Update is used to support SPP reliability studies and ERAG MMWG Dynamic model requirements. It is important for all generating entities that interconnect to the SPP transmission to support the Regional Transmission Organization with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic Model Format is PSS®E dynamics DYRE and RAWD formats.

The Dynamics Model data includes:
1. Steady-State models
2. Dynamics model data in Siemens PTI PSS®E DYRE format
3. User written model source and object code (includes wind farms)
4. ERAG MMWG System Dynamics Database (SDDB)
5. SDDB data update worksheet

SPP MDWG Dynamic Models are published according to the schedule in Section 15 B.
**MODEL DEVELOPMENT**

**Data Preparation**
The following section describes important items that must be followed in the development of a steady-state model in preparing the data for publishing new models or updating existing models.

1. The data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the [NERC](https://www.nerc.gov) website.
2. MOD data should be kept current for each pass during the MDWG model build.
3. The Data Submittal Workbook contains informational data as well as modeling data that Data Submitters shall keep current for each pass of the MDWG model build.
4. Transaction – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
5. Generator Data – Required generator data that is not otherwise captured in the models.
6. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
7. Load Mapping – Identify loads not served by native Control Areas.
8. Data Dictionary – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
9. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
10. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the data submittal workbook, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.

**Table 1: Season Date Range and Cutoff Dates**

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<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
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<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
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</table>

*Example of Winter: 12/1/2017 – 3/31/2018; yyyy+1 = 2018

**Steady-State and Short Circuit Data Format**

**PSS®E and MOD Users**
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.
Non-PSS®E and Non-MOD Users

For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

Dynamic Data Format

**PSS®E Users**

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyre file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

**Non-PSS®E Users**

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

**Responsible Entities**

Data owners are responsible for providing the data necessary to model their assets to its Transmission Planner(s) and Planning Coordinator(s) as described in this document. Data owners and their respective data submission responsibilities are noted in the NERC standard MOD-032-1.

1. **Generator Owners (GO) and Resource Planners (RP)** are responsible for submitting modeling data for their existing and future generating facilities respectively.
2. **Load Serving Entities (LSE)** are responsible for submitting modeling data for their existing and future load corresponding to the case types developed.
3. **Transmission Owners (TO)** are responsible for submitting modeling data for their existing and future transmission facilities.
4. The Planning Coordinator or Transmission Planner can request other information necessary for modeling purposes from the BA, GO, LSE, TO, or TSP.
Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Spring Peak</td>
<td>Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>Annual Summer Shoulder</td>
<td>Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>Annual Summer Peak</td>
<td>Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>Annual Fall Peak</td>
<td>Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>Annual Winter Peak</td>
<td>Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 April Minimum</td>
<td>Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>Annual + 1 Spring Peak</td>
<td>Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 Summer Shoulder</td>
<td>Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the *Annual Models* table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission to data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

Transactions modeled in all base cases should be limited to expected firm schedules and should not include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

**Load Forecast**

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be Non-Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.
A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand. DSM consists of controllable and non-controllable systems. Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. Distributed Energy Resources are power resources on the distribution system that can be aggregated together to provide power to meet Demand. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the SPP Open Access Transmission Tariff (OATT) shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed Interconnection Agreement (IA), or are in the process of finalizing an IA should be included in the Data Submitter’s load forecast. SPP will reject any MOD projects or PSS® E idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to appropriately tag MOD load projects in MOD.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the SPP Open Access Transmission Tariff (OATT) shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed agreement, or are in the process of finalizing a signed agreement should be included in the Data Submitter’s load forecast. SPP may reject any MOD projects or PSS® E idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.
Summary of Data Submitter’s load forecast data comprisal:

1. Non-coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

Seasonal peak models developed by SPP include: Summer Peak, Winter Peak, Spring Peak, and Fall Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority coincident peak.

In addition to the seasonal peak models, SPP develops two off-peak models. They include: a Light Load condition and a Summer Shoulder condition.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder model, also known as the seasonal on-peak average model is defined to be 70% - 85% of the total Summer Peak load level depending on the Data Owner/Data Submitter system.

Spring Peak (G): April 1st through May 31st
Summer Peak (S): June 1st through September 30th
Fall Peak (F): October 1st through November 30th
Winter Peak (W): December 1st through March 31st
Light Load (L): April 1st through May 31st
Shoulder (SH): 70% - 85% of Summer Peak model

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.

Area Summary Report

The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.

3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.

4. The case year and season should be entered in the appropriate locations in chronological order.

5. The current system official load forecast should be entered as net load (Item 6).

6. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.

7. Load equals net load minus estimated losses (Item 4).

8. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

9. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**

Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed.

This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,

2. The in-service and out-of-service dates, if applicable,

3. Tie line characteristics and ratings

4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie's steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**

Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several
future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The "from bus," "to bus," and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The "from bus" is assumed to be the metered end (unless the "to bus" is entered with a negative) and the "to bus" area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the "from bus" or first bus number after the change code. The "from bus" is the metered end unless the "to bus" or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance data shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be divided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each SPP member shall rate transmission circuits in accordance with the SPP Planning Criteria (Section 7.2). This criterion calls for each member to compute, at a minimum, summer and winter seasonal ratings for each circuit element. Each Base Case (Network) and Project branch, two-winding and three-winding transformer must have a specified rate A (normal) and rate B (long-term emergency) for spring, summer, fall, and winter. The ratings data format is in the MOD Procedure Manual.

6. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

7. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate
Megawatt-mile for the SPP Regional Tariff. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

8. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

9. Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. Any changes to bus names or numbers will be documented on the SPP Expanded bus name list. This will include renumbering buses as well as adding new or removing old buses from the models. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. The SPP Expanded bus name list can be used as a quick reference for new names. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

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Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
NOTE: When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable steady-state model(s) within the Project.

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. As previously mentioned, the bus names and numbers should remain constant unless there is a particular reason for changing them. This will aid the consistency of the models developed. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The eighth last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

1. - Below 69 kV
2. - 69 kV
3. - 115 kV
4. - 138 kV
5. - 161 kV
6. - 230 kV
7. - 345 kV
8. - 500 kV
9. - 765 kV or above

The ninth through twelfth character fields of the bus name are reserved for the base kV designation (right justified). As associated with the voltage code, the generally used kV values are: 69.0, 115, 138, 161, 230, 345, 500 and 765.

1. For generator regulated buses, a desired voltage magnitude will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be
given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent "hunting" of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.

**Load Data**

Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The Non-Scalable Loads will be identified in the Non-Scalable Load worksheet of the Data Submittal Workbook. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the Data Submittal Workbook.

**Generator Data**

Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and Mbase limits per testing requirements in SPP Planning Criteria 7.1.1. Generator MW shall be set to "gross" level with auxiliary load modeled explicitly. Qmax and Qmin values in the models should be based on unit test data. Intermittent resources (e.g., wind and run-of-river hydro) should not normally be dispatched beyond their net capability as established by SPP Planning Criteria 7.1 for the summer and shoulder cases. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the sub unsaturated transient impedance for those generators modeled by sub transient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine Base (MBASE) and Zero Impedance (ZSOURCE) values for the steady-state models must match dynamic data. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X''di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the Data Submittal Workbook.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.

**Shortfall Guidance Process**

A shortfall is defined as an instance of insufficient firm resource to supply firm load. Under no
circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the data submittal workbook.

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements:
   a. The in-service date shall be based on the expected in-service date of the GI study.
   b. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of exploratory generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

Note: The Generator Data worksheet data will be maintained to provide a convenient source of data for Member and SPP Staff use. Therefore accurate data in the Generation workbook is imperative. The official SPP generator data is in the MOD Base Case or Project.

Remote Generation Modeling

Purpose
This procedure assures that members adhere to a uniform process when modeling remote generation in SPP.

Modeling Process
If a member acquires remote generation outside their Control Area (steady-state model numbered area), the following modeling process should be followed:

1. All buses should be assigned numbers that are in the host’s control area bus number range.
2. Area Number/Name should be the host’s control area number.
3. Zone Number/Name should be in the host’s control area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

**Transaction Update**

The transaction workbook should be updated to show a transaction from the control area where remote generation is located to the generation owner control area. If the remote generation is owned by multiple owners, then multiple transactions should be modeled.

**Steady-State Data Check List**

The steady-state data check list should be used as an aid for ensuring good model data. As the data and preliminary runs are reviewed for each model, the items should be checked off. A copy of this form can be found in Section 7.

**Facilities Transferred to SPP’s Functional Control**

The SPP FERC "Docket No. RT04-01-00 Volume 1", In the July 2 Order, the Commission: ...(7) ordered that SPP file a list of all transmission facilities that will be transferred to its operational control and revise the Operational Authority White Paper ("OA White Paper") or Membership Agreement, or provide some other binding document, to reflect SPP’s clear authority to exercise day-to-day control over the appropriate transmission facilities within its footprint...

Attachment AI to the SPP Regional Tariff contains the criteria for inclusion of facilities that are considered "Facilities Transferred to SPP’s Functional Control". Transmission facilities meeting the definition set forth in Attachment AI must be included in the SPP MDWG Steady-State Models.

**Owner Data and Line Mileage Data (SAS-70 Control)**

Per SAS-70 requirements (i.e. - Loss calculation) SPP Loss models must be updated every June and October with current Owner Data and Line Mileage data. To meet the SAS-70 requirement the SPP models must include owner data and line-mileage data. SPP Staff will obtain this data from the MOD Base Case and Projects; therefore; it is important that Members keep the data current in MOD.

**Zone Range Assignments**

**SPP Area**

Refer to the most current SPP Area Zone Assignments.

**MMWG Region**

<table>
<thead>
<tr>
<th>Region</th>
<th>Bus Numbers</th>
<th>Area Numbers</th>
<th>Zone Numbers</th>
<th>Owner Numbers</th>
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</table>
Data Transmittal

Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- [GlobalScape](http://www.globalscape.com)

2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the "SPP MDWG File Sharing Site", [GlobalScape](http://www.globalscape.com). Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).
4. **Network**

Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**

The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**

   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**

   Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

   Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

   The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

   Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A, for guidelines of typical transmission line or transformer impedance data.
b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the Data Submittal Workbook.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

- i. \( QT \text{ --- } \text{MAX} = \text{one-half of MW rating} \)
- ii. \( QB \text{ --- } \text{MIN} = \text{negative one-third of MW rating} \)

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent
representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).

Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD, some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...). There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

   It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.
The most current update to the models will always be posted on the SPP file sharing site.

**Program Operation**

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

**PTI-PSS®E Data Format**

Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data for that bus will be removed (e.g., branches, transformers, generators, and loads). The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified. Data currently in the model is used as the default value for data fields not specified in the format.
Steady-State Solution

The steady-state solution will have "Area interchange control" with the "Tie Line and Loads" option selected to meet ERAG MMWG model building requirements.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area's number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

<table>
<thead>
<tr>
<th>No Transaction Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Area: XXX</td>
</tr>
<tr>
<td>Sink Area: YYY</td>
</tr>
<tr>
<td>Sink Load: XXX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transaction Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Area: XXX</td>
</tr>
<tr>
<td>Sink Area: YYY</td>
</tr>
<tr>
<td>Sink Load: YYY</td>
</tr>
</tbody>
</table>

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.
TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data. The sequence data is comprised of positive, zero, and negative sequence data. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For GSUs that are not retired with the associated generator, the appropriate status should be reflected in the model in order to produce accurate short circuit results.

*Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).* The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.
**SPP Data**

**Typical Transmission Line or Transformer Impedance**

These tables are only for the checking of reasonableness of line and transformer data and should not be used in data preparation for existing facilities.

**Typical Transmission Line Data**

<table>
<thead>
<tr>
<th>kV</th>
<th>Amps</th>
<th>R/mile</th>
<th>X/mile</th>
<th>(Mvar/mile)</th>
<th>Charging</th>
<th>MVA</th>
<th>X/R</th>
</tr>
</thead>
<tbody>
<tr>
<td>69</td>
<td>600</td>
<td>0.00540</td>
<td>0.0143</td>
<td>0.00030</td>
<td>71</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>115</td>
<td>2000</td>
<td>0.00064</td>
<td>0.0056</td>
<td>0.00084</td>
<td>246</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>138</td>
<td>2000</td>
<td>0.00045</td>
<td>0.0026</td>
<td>0.00120</td>
<td>296</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>161</td>
<td>2000</td>
<td>0.00020</td>
<td>0.0010</td>
<td>0.00020</td>
<td>552</td>
<td>1.2</td>
<td>1.2</td>
</tr>
<tr>
<td>230</td>
<td>2000</td>
<td>0.00038</td>
<td>0.0018</td>
<td>0.00040</td>
<td>958</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>245</td>
<td>2000</td>
<td>0.00020</td>
<td>0.0010</td>
<td>0.00045</td>
<td>1006</td>
<td>4.3</td>
<td>4.3</td>
</tr>
<tr>
<td>345</td>
<td>2000</td>
<td>0.00002</td>
<td>0.0002</td>
<td>0.00010</td>
<td>2252</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

**Typical Transmission Line Data (100 MVA BASE)**

A typical transmission transformer’s impedance is approximately 8% on the 100 MVA rating base.

For example:

On a 345 kV Line that is 70 miles long—

- R is: $70(0.00004) = 0.0028$
- X is: $70(0.00048) = 0.0336$
- Charging is: $70(0.0091) = 0.637$

**System Abbreviations & Area Number Assignments**

System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

**SPP Members**

The SPP Members are identified on the SPP Website. See the “Members” link under “About SPP” on www.SPP.org.
## FORMS – Area Summary Report

### POWER FLOW DATA AREA SUMMARY REPORT

<table>
<thead>
<tr>
<th>CASE</th>
<th>Area Name &amp; Number</th>
<th>Prepared By</th>
<th>Telephone Number</th>
</tr>
</thead>
</table>

1. **Generation**

Purchases (-)/Sales (+)

To/From Area Name

2. **Total Interchange**

3. **Net Power** (1-2)

4. **Load**

5. **Losses**

6. **Net Load** (4+5)

7. **Slack Bus Generation**

8. **Slack Bus Number & Name**

*Note:*
### FORMS – Steady-State Data Checklist

<table>
<thead>
<tr>
<th>CASE</th>
<th>BUS DATA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Names - 12 characters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage Codes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power Factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load - Real</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive Load</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Voltage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed Shunts - Reactors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capacitors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dynamic Shunts - SVC’s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchronous Condensors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation - Dispatch/Net</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive Output</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactive Limits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regulated Voltages</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generator Rating</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slack Bus</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LINE DATA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ratings - Normal</td>
<td></td>
</tr>
<tr>
<td>Emergency</td>
<td></td>
</tr>
<tr>
<td>Impedance - Resistance</td>
<td></td>
</tr>
<tr>
<td>Reactance</td>
<td></td>
</tr>
<tr>
<td>Charging</td>
<td></td>
</tr>
<tr>
<td>Flows</td>
<td></td>
</tr>
<tr>
<td>Transformers - Taps</td>
<td></td>
</tr>
<tr>
<td>Tap Ranges</td>
<td></td>
</tr>
<tr>
<td>Regulated Bus</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>OTHER DATA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Net - Area Interchange</td>
<td></td>
</tr>
<tr>
<td>Area Transactions</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**
ACRONYMS

ATC – Available Transfer Capability
CAP – Capacitor
EIA – Energy Information Act
ERAG – Eastern Interconnection Reliability Assessment Group
ERCOT – Electric Reliability Council of Texas
FPC – Federal Power Commission
IDEV – Input Device (PSS®E Dialog Input Device Selection Activity)
LTC – Load Tap Changing
MAPP – Mid-Continent Area Power Pool
MAIN – Mid-American Interpool Network
MBASE – Machine Base
MDWG – Model Development Working Group
MMWG – Multiregional Modeling Working Group
Mvar – Megavar
MW – Megawatt
NERC – North American Electric Reliability Corporation
PSS®E – Power System Simulator for Engineers
PTI – Power Technologies, Inc.
pu – Per-unit
RAWD – Raw Data
RDCH – Read Change (Command to read in and change data in PSS®E)
REAC – Reactor
SERC – Southeastern Electric Reliability Council
SPP – Southwest Power Pool, Inc.
STEP – SPP Transmission Expansion Plan
TWG – Transmission Working Group
WSCC – Western Systems Coordinating Council
ZSOURCE – Zero Impedance

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at www.spp.org.
See the “Glossary and Acronyms” link under “Training”
MDWG Contact List
The MDWG Contact List can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

SPP Model Release Guidelines

Steady-State and Short Circuit Models
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If equivalized, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.

System Dynamic Data Base and Dynamic Simulation Cases
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.

SPP Model Contact
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

If you are an SPP member, interconnection customer, transmission service customer (or their consultant) and would like to request an SPP Transmission Map or Model, please complete the appropriate forms below. (Requests for Joint & Interregional System Planning Models are addressed on this page.) If you are requesting access on behalf of an organization other than your employer, a Consultant Authorization Form must also be submitted on your behalf.

SPP Transmission Map Order Form
SPP Model Order Form
SPP Confidentiality Agreement
Consultant Authorization Form


If you have obtained FERC CEII approval and would like to request additional CEII, please submit the appropriate SPP Form(s) and SPP Confidentiality Agreement, providing the requester’s FERC CEII ID Number and attaching a copy of the FERC Authorization Letter (i.e., FERC Notice of Intent to Release).

Completed SPP Forms and the SPP Confidentiality Agreement should be e-mailed to SPP Customer Relations. The original, signed hardcopy of the SPP Confidentiality Agreement should be mailed to the attention of Susan Polk, 201 Worthen Drive, Little Rock, Arkansas 72223.

If you have questions or would like additional assistance, please contact SPP Customer Relations at (501) 614-2309.

Last Updated June-July 2015-2018
**MDWG Case Type Set**
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

**Error Screening**
The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected.*
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

   The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

---

**Dynamics Data Submittal Requirements and Guidelines**

**Steady-State Modeling Requirements**

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the
step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the Xsource value in the steady-state generator data record shall be as follows:
   a. \( X_{\text{source}} = X''_d \) for detailed synchronous machine modeling
   b. \( X_{\text{source}} = X'_d \) for non-detailed synchronous machine modeling
   c. \( X_{\text{source}} = \) should be equal to locked rotor impedance for an induction machine
   d. \( X_{\text{source}} = 1.0 \) per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E dynamic library models compatible with either representation are available. If a user model representing particular SVC and control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

Dynamic Modeling Requirements

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The PSS®E dynamic model types classified as detailed are GENROU, GENSAL, GENROE, GENSAE, and GENDCO.

   The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.

   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.

   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.

c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.

d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of
cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

Dynamics Data Validation Requirements
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual ('yet to be written) may be applied for this purpose.

Guidelines
1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).
2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PT1PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.
**Procedures for Submission of Dynamics Data to the MMWG Coordinator**
Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

**Dynamics Data Updates Using Excel Template**
Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready. The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another model of the same equipment group</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes</td>
<td>1. A DC exciter is replaced by a static exciter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. A classical machine model is replaced by a detailed model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all models of an existing unit</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
</tr>
<tr>
<td>Change bus number</td>
<td>No</td>
<td>No</td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
</tr>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
<td>Same requirements whether unit is at new or existing bus.</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Complete Set of Dynamics Data**
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.
MMWG Deliverables

Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format; regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   a. Initialized steady state and regional contingency cases.
      i. Steady-State RAWD case file
      ii. Conversion IDEV files

2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports
SECTION 2: STEADY-STATE MODELING

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5, and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using R=0.00000 + X=0.0001 and B=0.00000. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of R=0.0001 + X=0.002 and B=0.00000. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – Effective with Revision 28 of PSS®E, off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding. The measured impedance (resistive and inductive) between each pair of windings shall be specified: data entry options permit these to be entered in (1) per unit on system (100 MVA) base, (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage.
9. Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

10. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

11. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes.

PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:

a. Real-time operational auto or manual adjustment operation of the PST.
b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
c. Real-time operational MW flow limits (e.g. ±20 MW).
d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
f. Applicable long-term firm transmission service levels for the PST.

12. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

13. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled
explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

14. Out-of-Service Generator Modeling – Out-of-service generators should be modeled with a STATUS equal to zero.

15. Generator MW Limits – The generation capability limits specified for generators (PMIN and P MAX) should represent realistic seasonal unit output capability for the generator in that given base case. P MAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and Q MAX) should represent realistic net unit output capability of the generator modeled. Q MAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

17. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

18. Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

19. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit, should be avoided.

20. Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

21. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

22. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough
that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

23. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point and equipment status, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation.

24. HVDC – All HVDC transmission facilities must be represented with a sufficiently detailed model to simulate its expected behavior.

25. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

26. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence
1. A line whose impedance is very small as compared to that of a line connected in series with it.
   (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)
2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.
3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during equivalencing.
4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.
5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.
6. Unrealistic tap changing transformer tap limits.
7. Radial system is very large.
8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.
10. Not solvable from flat start.
11. Fictitious regulation of buses.
12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.
14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.
15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Problems

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.
SECTION: PROCEDURES FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or -9999.
   c. Checks which report abnormal values
      i. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      ii. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      iii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      iv. Branches with extreme impedances or tap ratios [BRCH]. Suggested options are:
         a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
         b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
         c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.
d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]

c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].

e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)

a. Specify CONEC, CONET, and COMPILE files.

b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using “user dynamics”.

a. Read converted load flow [CASE].

b. Read in the dynamic data file [DYRE]

c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.

d. Check consistency of dynamic models [DYCH, option 1].
e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
   i. Warning messages for
      a) Generators in the load flow for which there is no active machine model.
      b) Models, usually of excitation systems or governors, initialized out of limits.
      c) The number of iterations required to initialize the initial-conditions steady-state.
   
   ii. A tabulation of conditions at each online machine
      a) Terminal voltage
      b) Exciter output voltage
      c) Real and reactive power output
      d) Power factor
      e) Machine angle in degrees
      f) Direct and quadrature axis currents on machine base.

   iii. A diagnosis of initial conditions, either
      a) "Initial conditions check OK", or
      b) A listing of suspect initial conditions generally states whose time derivative is not "small" (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.

   iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

   f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.
11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.
13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 "non-continuous" regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain
equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((- K) = (-1 / R)\), mechanical power to \((1-1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Compliance

1. MDWG Model Development Procedure Manual  
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list  
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)  
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,  
From Area Name,
From Bus#,  
From Bus Name,
From Bus kV,
To Region Name,
To Area#,  
To Area Name,
To Bus#,  
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI (pu),
BI (pu),
GJ (pu),
BJ (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#, 
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS {0,1},
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM11,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#,
Winding 1 Area Name,
Winding 1 Bus#,
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#,
Winding 2 Area Name,
Winding 2 Bus#,
Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#,
Winding 3 Area Name,
Winding 3 Bus#,
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBASE2-3,
R3-1,
Three Winding Transformer Data Fields - continued

X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
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Control Bus 1 Area Name,
Control Bus #(CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RMI1,
VMA1,
VM1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued

RMI2,
VMA2,
VMI2,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RMI3,
VMA3,
VMI3,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields

In Service Date, 
Out Service Date, 
I, 
MDC, 
RDC, 
SETVL, 
VSCHD, 
VCMOD (1,0), 
RCOMP, 
DELTI, 
METER (R,I), 
DCVMIN, 
CCCIITMX, 
CCCACC, 
IPR REGION NAME, 
IPR AREA#, 
IPR AREA NAME, 
IPR Bus#, 
IPR BUS NAME, 
IPR BUS kV, 
NBR, 
ALFMX, 
ALFMN, 
RCR, 
XCR, 
EBASR, 
TRR, 
TAPR, 
TMXR, 
TMNR, 
STPR, 
ICR REGION NAME, 
ICR AREA#, 
ICR AREA NAME, 
ICR BUS#, 
ICR BUS NAME, 
ICR BUS kV, 
IFR REGION NAME, 
IFR AREA#, 
IFR AREA NAME, 
IFR BUS#, 
IFR BUS NAME, 
IFR BUS kV, 
ITR REGION NAME, 
ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAPR,
IPI REGION NAME,
IPI AREA#, 
IPI AREA NAME,
IPI Bus#, 
IPI BUS NAME,
IPI BUS Kv,
NBI,
GAMMX,
GAMMN,
RCI,
XCI,
EBASI,
TRI,
TAPI,
TMXI,
TMNI,
STPI,
ICI REGION NAME,
ICI AREA#, 
ICI AREA NAME,
ICI BUS#, 
ICI BUS NAME,
ICI BUS KV,
IFI REGION NAME,
IFI AREA#, 
IFI AREA NAME,
IFI BUS#, 
IFI BUS NAME,
IFI BUS KV,
ITI REGION NAME,
ITI AREA#, 
ITI AREA NAME,
ITI BUS#, 
ITI BUS NAME,
ITI BUS KV,
IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements. 
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
SECTION: APPENDIX II
NUMBER RANGE ASSIGNMENTS FOR ERAG
MMWG STEADY-STATE DATA

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<th>Zone Numbers</th>
<th>Owner Numbers</th>
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1 Area or zone number 1 is sometimes used as a default when the number is omitted by mistake. Its use to number an actual area should be avoided.
## SECTION: APPENDIX III

### UTILIZED IMPEDANCE CORRECTION TABLES

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### SYSTEM CODES FOR USE IN ERAG MMWG STEADY-STATE DATA

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**RFC – Reliability First Corporation**

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### FRCC Florida Reliability Coordination Council

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# Area # | ID | System
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503 | LAFA | Lafayette Utilities
504 | LEPA | Louisiana Energy and Power Authority
505 | ALEX | City of Alexandria
507 | RAYB | Rayburn Country Electric Cooperative
508 | NTEC | North Texas Electric Cooperative
509 | SRGT | Sam Rayburn G&T
511 | AREC | Arkansas Electric Cooperative
513 | CLWL | City of Clarksdale
514 | MEAM | Municipal Energy Agency of Mississippi
515 | SWPA | Southwestern Power Administration
520 | AEPW | American Electric Power
522 | KAMO | Kamo Electric Cooperative
523 | GRDA | Grand River Dam Authority
524 | OKGE | Oklahoma Gas and Electric Company
525 | WFEC | Western Farmers Electric Cooperative
526 | SPS | Southwestern Public Service
527 | OMPA | Oklahoma Municipal Power Authority
531 | MIDW | Midwest Energy
534 | SUNC | Sunflower Electric Cooperative
536 | WERE | Westar
537 | SIKE | City of Sikeston, Missouri
539 | WEPL | Westplains Energy
540 | MEPU | Missouri Public Service Company
541 | KAPL | Kansas City Power and Light Company
542 | KACY | Board of Public Utilities
544 | EMDE | Empire District Electric Company
545 | INDN | City of Independence
546 | SPRM | City Utilities of Springfield
### MRO – Midwest Reliability Organization

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<td>DPC</td>
<td>Dairyland Power Cooperative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WPCI Wisconsin Public Power Inc.</td>
</tr>
<tr>
<td>694</td>
<td>ALTE</td>
<td>Alliant Energy East (ATC)</td>
</tr>
<tr>
<td>696</td>
<td>WPS</td>
<td>Wisconsin Public Service Corporation (ATC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CWP Consolidated Water Power Company (ATC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MEWE Marshfield Electric and Water Company (ATC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MPU Manitowoc Public Utilities (ATC)</td>
</tr>
<tr>
<td>697</td>
<td>MGE</td>
<td>Madison Gas and Electric Company (ATC)</td>
</tr>
<tr>
<td>698</td>
<td>UPPC</td>
<td>Upper Peninsula Power Company (ATC)</td>
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### ERCOT & WECC

<table>
<thead>
<tr>
<th>Area #</th>
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<th>System</th>
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<tr>
<td>700</td>
<td>ERCOT</td>
<td>Electric Reliability Council of Texas, Inc.</td>
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<tr>
<td>800</td>
<td>WECC</td>
<td>Western Electricity Coordinating Council</td>
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</table>
**SECTION: APPENDIX VI**

**MOD-032-1 – ATTACHMENT 1**

The table below indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>(Items marked with an asterisk indicate data that vary with system operating state or conditions. These items may have different data provided for different modeling scenarios)</em></td>
<td><em>(If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</em></td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>1. Each bus [TO]</td>
<td></td>
<td>a. Positive Sequence Data</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td></td>
<td>b. Negative Sequence Data</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td></td>
<td>c. Zero Sequence Data</td>
</tr>
<tr>
<td>2. Aggregate Demand 13 <strong>[LSE]</strong></td>
<td></td>
<td>2. Mutual Line Impedance Data <strong>[TO]</strong></td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td></td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Generating Units 14 <strong>[GO, RP]</strong> for future planned resources only)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide data in the same)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2. For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3. Including synchronous condensers and pumped storage.
<p>| | |</p>
<table>
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<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>d.</td>
<td>regulated bus* and voltage set point* (as typically provided by the TOP)</td>
</tr>
<tr>
<td>e.</td>
<td>machine MVA base</td>
</tr>
<tr>
<td>f.</td>
<td>generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
</tr>
<tr>
<td>g.</td>
<td>generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
</tr>
<tr>
<td>h.</td>
<td>in-service status*</td>
</tr>
<tr>
<td></td>
<td>necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
</tbody>
</table>

### 4. AC Transmission Line or Circuit [TO]

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>a.</td>
<td>impedance parameters (positive sequence)</td>
</tr>
<tr>
<td>b.</td>
<td>susceptance (line charging)</td>
</tr>
<tr>
<td>c.</td>
<td>ratings (normal and emergency)*</td>
</tr>
<tr>
<td>d.</td>
<td>in-service status*</td>
</tr>
</tbody>
</table>

### 5. DC Transmission systems [TO]

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>nominal voltages of windings</td>
</tr>
<tr>
<td>b.</td>
<td>impedance(s)</td>
</tr>
<tr>
<td>c.</td>
<td>tap ratios (voltage or phase angle)*</td>
</tr>
<tr>
<td>d.</td>
<td>minimum and maximum tap position limits</td>
</tr>
<tr>
<td>e.</td>
<td>number of tap positions (for both the ULTC and NLTC)</td>
</tr>
<tr>
<td>f.</td>
<td>regulated bus (for voltage regulating transformers)*</td>
</tr>
<tr>
<td>g.</td>
<td>ratings (normal and emergency)*</td>
</tr>
<tr>
<td>h.</td>
<td>in-service status*</td>
</tr>
</tbody>
</table>
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits\(^*\) (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus\(^*\) (if mode of operation not fixed)
   e. in-service status\(^*\)

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point\(^*\)
   c. fixed/switched shunt, if applicable
   d. in-service status\(^*\)

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
SECTION: APPENDIX VII

Modeling of Generator Parameters

1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

Modeling Process for Generator Parameters
   a. The Generator parameter $P_{\text{MAX}}$ shall be modeled as a gross seasonal maximum capability based on MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.
   b. Generating plant station service and auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All station service and auxiliary load representations shall:
      i. Be modeled explicitly on the appropriate bus, corresponding to the voltage to which the auxiliary load is served. Model representations of auxiliary load connected to the generating unit bus (Figure VII-1), auxiliary load modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
      ii. Be annotated as non-scalable.

15 Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant auxiliary load.
c. Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

If generating plant station service and auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use “SS” in the Load ID field (Figure VII-4a). If there are more than one aggregated generating plant station service and auxiliary load, use “Sn” in the Load ID field to delineate the multiple aggregated loads.

If generating plant station service and auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “Fn” in the Load ID field\(^{16}\) to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “Vn” in the Load ID field\(^{4}\) to designate variable load quantities that do vary with plant dispatch.

---

**Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).**

---

\(^{16}\) “n” represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
• Light load models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility's latest five-year average (or replacement data if unavailable) for the SPP coincident off-peak hour corresponding to the season of the Light Load case, not to exceed each facility's firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility's long-term firm transmission service amount.

• Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility's latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility's firm service amount.

• SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build.

• When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

• Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

Data Exemption Process

MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the "Exemption Form" and send it via e-mail to "Engineering Modeling” containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.
**Effective date of section 2 is July 1, 2016.
**Effective date of section 4 is July 1, 2016.

17 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
SECTION: APPENDIX VIII - BALANCING AND TRANSACTIONS

Background

A core principal of steady-state power flow modeling\(^\text{18}\) is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area\(^\text{19}\). While typically analogous to a Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\(^\text{20}\) loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

\(^\text{18}\) The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

\(^\text{19}\) Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).

\(^\text{20}\) ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch ($P_{gen}$) of each non-slab generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from
imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG Data Submittal Workbook. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models,

Figure 2. Four types of inter-SPP pseudo-ties.
external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:

a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

![Diagram showing inter-area transfer](image)

**Inter-area Bilateral transaction description**

Data Owner A exports MW to Data Owner B  
Data Owner B imports MW from Data Owner A

**Transaction accounting in Data Submittal Workbook**

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
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<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
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<td>3/1/2020</td>
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<tr>
<td>Non-SPP</td>
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<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>2</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
</tr>
</tbody>
</table>

*Figure 3. Example of inter-area transfer (transaction).*
6. Complete the following required Data Submittal Workbook data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate Data Submittal Workbook field.

8. The following Data Submittal Workbook information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.
## REVISION HISTORY

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<th>CHANGE DESCRIPTION</th>
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<td>Updated format</td>
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</tr>
<tr>
<td>2018 v1.1</td>
<td>SPP Engineering Modeling</td>
<td>Modified Bus Naming and Map / Model request information</td>
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<td>2018 v1.2</td>
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, data owners, equipment, and data submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator's planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC's Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.
Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1)¹, and the provisions of the SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners² of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority³ and Transmission Service Provider for the SPP Transmission System.

Applicable Data Owners
A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

1. The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
2. Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.
3. For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.

• Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.

• Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.
Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization (“ERO”), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (<2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise,

5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Equivalencing is a general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.
8 Sixth Revised Volume No.1, Attachment AI, Part II-1.
9 Sixth Revised Volume No.1, Attachment AI, Part II-2.
10 Sixth Revised Volume No.1, Part III-30.
11 Sixth Revised Volume No.1, Part III-31.
consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted. Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

Accountability

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- Appropriate lead times. Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes. In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
General Data Reporting Responsibilities

The SPP data reporting entities are responsible for the following categories of system modeling data:

1. Steady-State
2. Short Circuit
3. Dynamics

Steady-State models are developed for an annual series of SPP cases, including an annual series of ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by SPP Regional Tariff and Planning Criteria.

Short Circuit models are developed annually using a subset of the Reliability Steady-State models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

The Dynamics Model is also updated annually with current generator unit information. Steady-State models are used in conjunction with dynamic data to run dynamic simulation.

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.
Entities in the SPP Planning Coordinator region that are not members of the SPP but required to submit data (i.e. IPPs, Municipalities) will submit data directly to the Transmission Owner or Balancing Authority in which their system resides. Upon review (i.e. data accuracy, quality) by the Transmission Owner or Balancing Authority the data will then be provided to the SPP during the annual MDWG case type update process. The data submitted will be in the standard PTI format as specified in the MDWG Model Development procedure manual. All non-SPP members that are responsible for submitting this data should directly coordinate with the Transmission Owner or Balancing Authority on timing for sending data, as well as any special requirements in data formatting.

In an effort to determine who is collecting/submitting data for whom, all NERC registered entities within the SPP PC footprint (MOD-032-1: applicable to BA, GO, LSE, RP, TO, TP, and TSP) shall fill out the data coordination workbook to notify SPP if data is being submitted directly to SPP or through some other entity(ies) on behalf of your company. Likewise, SPP shall be notified if your company is submitting data on behalf of another entity(ies).

Confidentiality and Proprietorship

The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

Schedule

As with all schedules, the meeting of deadlines is most critical. All system representatives must familiarize themselves with the schedule well in advance of all deadlines. This will alleviate any problems with the timing of data submittal and data reviews. The schedule for model development will be sent with the first data request as well as posted on the SPP corporate website, www.spp.org.

Steady-State and Short Circuit Model Development

The MDWG Steady-State and Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the EDST Data Submittal Workbook. MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the EDST Data Submittal Workbook which is identified in the data preparation section of this manual.

SPP MDWG Steady-State and Short Circuit Models are published according to the approved schedule.

AC Contingency Analysis

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set.
The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.

**Dynamic Model Development**

**Introduction**
The MDWG Dynamic Models include full MMWG cases and machine reduced cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model Update is used to support SPP reliability studies and ERAG MMWG Dynamic model requirements. It is important for all generating entities that interconnect to the SPP transmission to support the Regional Transmission Organization with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic Model Format is PSS®E dynamics DYRE and RAWD formats.

The Dynamics Model data includes:

1. Steady-State models
2. Dynamics model data in Siemens PTI PSS®E DYRE format
3. User written model source and object code (includes wind farms)
4. ERAG MMWG System Dynamics Database (SDDB)
5. SDDB data update worksheet

SPP MDWG Dynamic Models are published according to the schedule in Section 15 B.
MODEL DEVELOPMENT

Data Preparation
The following section describes important items that must be followed in the development of a steady-state model in preparing the data for publishing new models or updating existing models.

1. The data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.
2. MOD data should be kept current for each pass during the MDWG model build.
3. The Data Submittal WorkbookEDST contains informational data as well as modeling data that Data Submitters shall keep current for each pass of the MDWG model build.
4. Transaction – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
5. Generator Data – Required generator data that is not otherwise captured in the models.
6. SPP Modeling Assignments – Contains PSSE modeling area, owner, zone, and bus range information pertinent to SPP.
7. Load Mapping – Identify loads not served by native Control Areas.
8. Data Dictionary – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
9. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
10. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the data submittal workbookEDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.

Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of Winter: 12/1/2017 – 3/31/2018; yyyy+1 = 2018

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.
Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

Dynamic Data Format

PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyre file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

Non-PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

NERC maintains a list of acceptable excitation and governor system models on the NERC website for reference by the GO. The acceptable list can be found on the NERC SAMS website→SAMS Reference Materials→NERC Acceptable Model List.

Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:

1. Technical justification as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis.
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment to SPP and the applicable Transmission Planner(s) indicating that user-written models will be either: 1) replaced with standard library models; or 2) added to the PSSE/PSLF set of standard dynamic models within one year of the following applicable event:
   a. The date of commercial operation for planned facilities with an executed GIA
   b. The date of receipt of notification for existing facilities
For existing facilities, a written commitment within 1 year, user-written model that can be added to the PSSE and PSLF standard Dynamic Model libraries.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Responsible Entities
Data owners are responsible for providing the data necessary to model their assets to its Transmission Planner(s) and Planning Coordinator(s) as described in this document. Data owners and their respective data submission responsibilities are noted in the NERC standard MOD-032-1.

1. Generator Owners (GO) and Resource Planners (RP) are responsible for submitting modeling data for their existing and future generating facilities respectively.
2. Load Serving Entities (LSE) are responsible for submitting modeling data for their existing and future load corresponding to the case types developed.
3. Transmission Owners (TO) are responsible for submitting modeling data for their existing and future transmission facilities.
4. The Planning Coordinator or Transmission Planner can request other information necessary for modeling purposes from the BA, GO, LSE, TO, or TSP.

**Typical Annual Models**

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission to data and list of MDWG models (case types) can be found on the SPP
Transactions modeled in all base cases should be limited to expected firm schedules and should not include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

**Load Forecast**

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be Non-Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand. DSM consists of controllable and non-controllable systems. Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. Distributed Energy Resources are power resources on the distribution system that can be aggregated together to provide power to meet Demand. For purposes of transmission
planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the SPP Open Access Transmission Tariff (OATT) shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed agreement, or are in the process of finalizing a signed agreement should be included in the Data Submitter’s load forecast. SPP may reject any MOD projects or PSSE idev projects that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Non-coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

Seasonal peak models developed by SPP include: Summer Peak, Winter Peak, Spring Peak, and Fall Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority coincident peak.

In addition to the seasonal peak models, SPP develops two off-peak models. They include: a Light Load condition and a Summer Shoulder condition.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder model, also known as the seasonal on-peak average model is defined to be 70% - 85% of the total Summer Peak load level depending on the Data Owner/Data Submitter system.

Spring Peak (G): April 1st through May 31st
Summer Peak (S): June 1st through September 30th
Fall Peak (F): October 1st through November 30th
Winter Peak (W): December 1st through March 31st
Light Load (L): April 1st through May 31st
Shoulder (SH): 70% - 85% of Summer Peak model

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.
**Area Summary Report**

The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. The case year and season should be entered in the appropriate locations in chronological order.
5. The current system official load forecast should be entered as net load (Item 6).
6. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
7. Load equals net load minus estimated losses (Item 4).
8. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.
9. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**

Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member **must** coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the
tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**

Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The “from bus,” “to bus”, and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance data shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be divided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each SPP member shall rate transmission circuits in accordance with the SPP Planning Criteria (Section 7.2). This criterion calls for each member to compute, at a minimum, summer and winter seasonal ratings for each circuit element. Each Base
Case (Network) and Project branch, two-winding and three-winding transformer must have a specified rate A (normal) and rate B (long-term emergency) for spring, summer, fall, and winter. The ratings data format is in the MOD Procedure Manual.

6. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

7. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the SPP Regional Tariff. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

8. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

9. Transformer connection codes12 and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

Bus Data

For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique.

12 Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).  

NOTE: When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

1 - Below 69 kV  4 - 138 kV  7 - 345 kV
2 - 69 kV  5 - 161 kV  8 - 500 kV
3 - 115 kV  6 - 230 kV  9 - 765 kV or above

1. For generator regulated buses, a desired voltage magnitude will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.
4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent "hunting" of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.

**Load Data**

Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The Non-Scalable Loads will be identified in the Non-Scalable Load worksheet of the Data Submittal WorkbookEDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the Data Submittal WorkbookEDST.

**Generator Data**

Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and Mbase limits per testing requirements in SPP Planning Criteria 7.1.1. Generator MW shall be set to "gross" level with auxiliary load modeled explicitly. Qmax and Qmin values in the models should be based on unit test data. Intermittent resources (e.g., wind and run-of-river hydro) should not normally be dispatched beyond their net capability as established by SPP Planning Criteria 7.1 for the summer and shoulder cases. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the sub unsaturated transient impedance for those generators modeled by sub transient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine Base (MBASE) and Zero Impedance (ZSOURCE) values for the steady-state models must match dynamic data. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X"di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the Data Submittal WorkbookEDST.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.
Shortfall Guidance Process

A shortfall is defined as an instance of insufficient firm resource to supply firm load. Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the [data submittal workbook](#).

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   a. The in-service date shall be based on the expected in-service date of the GI study.
   b. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of exploratory generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

Remote Generation Modeling

Purpose
This procedure assures that members adhere to a uniform process when modeling remote generation in SPP.

Modeling Process
If a member acquires remote generation outside their Control Area (steady-state model numbered area), the following modeling process should be followed:

1. All buses should be assigned numbers that are in the host's control area bus number range.
2. Area Number/Name should be the host's control area number.
3. Zone Number/Name should be in the host's control area zone range.
4. Generation Owner Number should be the owner's designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.
Transaction Update
The transaction workbook should be updated to show a transaction from the control area where remote generation is located to the generation owner control area. If the remote generation is owned by multiple owners, then multiple transactions should be modeled.

Steady-State Data Check List
The steady-state data check list should be used as an aid for ensuring good model data. As the data and preliminary runs are reviewed for each model, the items should be checked off. A copy of this form can be found in Section 7.

Facilities Transferred to SPP’s Functional Control
The SPP FERC "Docket No. RT04-01-00 Volume 1", In the July 2 Order, the Commission: ...(7) ordered that SPP file a list of all transmission facilities that will be transferred to its operational control and revise the Operational Authority White Paper ("OA White Paper") or Membership Agreement, or provide some other binding document, to reflect SPP's clear authority to exercise day-to-day control over the appropriate transmission facilities within its footprint...

Attachment AI to the SPP Regional Tariff contains the criteria for inclusion of facilities that are considered "Facilities Transferred to SPP's Functional Control". Transmission facilities meeting the definition set forth in Attachment AI must be included in the SPP MDWG Steady-State Models.

Owner Data and Line Mileage Data (SAS-70 Control)
Per SAS-70 requirements (i.e. – Loss calculations) SPP Loss models must be updated every June and October with current Owner Data and Line Mileage data. To meet the SAS-70 requirement the SPP models must include owner data and line-milage data. SPP Staff will obtain this data from the MOD Base Case and Projects; therefore; it is important that Members keep the data current in MOD.

Zone Range Assignments
SPP Area
Refer to the most current SPP Area Zone Assignments.

MMWG Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Bus Numbers</th>
<th>Area Number</th>
<th>Zone Number</th>
<th>Owner Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire System</td>
<td>100,000 to 899,999</td>
<td>110 to 899</td>
<td>100 to 1,899</td>
<td>100 to 1,199</td>
</tr>
<tr>
<td>NVEC</td>
<td>100,000 to 199,999</td>
<td>110 to 199</td>
<td>100 to 199 and 1,000 to 1,199</td>
<td>100 to 199</td>
</tr>
<tr>
<td>RFC</td>
<td>200,000 to 299,999</td>
<td>200 to 299</td>
<td>200 to 299 and 1,200 to 1,299 and 1,800 to 1,899</td>
<td>200 to 299</td>
</tr>
<tr>
<td>SERC</td>
<td>300,000 to 399,999</td>
<td>300 to 399</td>
<td>300 to 399 and 1,300 to 1,399</td>
<td>300 to 399</td>
</tr>
<tr>
<td>ERC</td>
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<td>400 to 499</td>
<td>400 to 499 and 1,400 to 1,499</td>
<td>400 to 499</td>
</tr>
<tr>
<td>SPP</td>
<td>500,000 to 599,999</td>
<td>500 to 599</td>
<td>500 to 599 and 1,500 to 1,599</td>
<td>500 to 599 and 800 to 899</td>
</tr>
<tr>
<td>MISO</td>
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<td>600 to 699</td>
<td>600 to 699 and 1,600 to 1,699</td>
<td>600 to 699</td>
</tr>
<tr>
<td>ERCOT (future)</td>
<td>700,000 to 799,999</td>
<td>700 to 799</td>
<td>700 to 799 and 1,700 to 1,799</td>
<td>700 to 799</td>
</tr>
</tbody>
</table>
Data Transmittal

Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- GlobalScape
2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the “SPP MDWG File Sharing Site”, GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads.
   The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).
4. **Network**

Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**

The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**

   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**

   Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

   Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

   The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

   Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.
b. **Summary of Overloaded Branches**
   This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**
   All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

   The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the Data Submittal Workbook EDST.

   The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

   The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:
   
   i. \( QT \text{ --- } \text{MAX} = \text{one-half of MW rating} \)
   
   ii. \( QB \text{ --- } \text{MIN} = \text{negative one-third of MW rating} \)

   If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

   The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

   Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent
representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).

Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)
Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)

Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI, IDEV format file to perform the RDCH operation. **This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.** It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.
The most current update to the models will always be posted on the SPP file sharing site.

**Program Operation**

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

**PTI-PSS®E Data Format**

Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data for that bus will be removed (e.g., branches, transformers, generators, and loads). The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified. Data currently in the model is used as the default value for data fields not specified in the format.
Steady-State Solution
The steady-state solution will have “Area interchange control” with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area’s number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

No Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.
TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data. The sequence data is comprised of positive, zero, and negative sequence data. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For GSUs that are not retired with the associated generator, the appropriate status should be reflected in the model in order to produce accurate short circuit results.

Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final). The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.
SPP Data

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

SPP Members
The SPP Members are identified on the SPP Website. See the "Members" link under "About SPP" on www.SPP.org.
### FORMS – Area Summary Report

#### SPP Southwest Power Pool

<table>
<thead>
<tr>
<th>CASE</th>
<th>POWER FLOW DATA AREA SUMMARY REPORT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Generation</td>
<td>Purchases (-)/Sales (+) To/From Area Name</td>
</tr>
<tr>
<td>2. Total Interchange</td>
<td></td>
</tr>
<tr>
<td>3. Net Power (1-2)</td>
<td></td>
</tr>
<tr>
<td>4. Load</td>
<td></td>
</tr>
<tr>
<td>5. Losses</td>
<td></td>
</tr>
<tr>
<td>6. Net Load (4+5)</td>
<td></td>
</tr>
<tr>
<td>7. Slack Bus Generation</td>
<td></td>
</tr>
<tr>
<td>8. Slack Bus Number &amp; Name</td>
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</table>

**Note:**

<table>
<thead>
<tr>
<th>Area Name &amp; Number:</th>
<th>Prepared By:</th>
<th>Telephone Number:</th>
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## FORMS – Steady-State Data Checklist

<table>
<thead>
<tr>
<th>CASE</th>
<th>POWER FLOW DATA CHECKLIST</th>
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</thead>
<tbody>
<tr>
<td>BUS DATA</td>
<td>Names - 12 characters</td>
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<tr>
<td></td>
<td>Voltage Codes</td>
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<tr>
<td></td>
<td>Power Factor</td>
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<td>Load - Real</td>
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<td>Reactive Load</td>
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<tr>
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<td>Voltage</td>
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<tr>
<td></td>
<td>Fixed Shunts - Reactors</td>
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<tr>
<td></td>
<td>Capacitors</td>
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<tr>
<td></td>
<td>Dynamic Shunts - SVC’s</td>
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<tr>
<td></td>
<td>Synchronous Condensors</td>
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<tr>
<td></td>
<td>Generation - Dispatch/Net</td>
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<tr>
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<td>Reactive Output</td>
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<td>Reactive Limits</td>
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<tr>
<td></td>
<td>Regulated Voltages</td>
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<td>Generator Rating</td>
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<td></td>
<td>Slack Bus</td>
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<tr>
<td>LINE DATA</td>
<td>Ratings - Normal</td>
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<tr>
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<td>Emergency</td>
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<tr>
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<td>Impedance - Resistance</td>
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<td>Reactance</td>
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<td>Charging</td>
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<tr>
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<td>Flows</td>
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<td>Transformers - Taps</td>
</tr>
<tr>
<td></td>
<td>Tap Ranges</td>
</tr>
<tr>
<td></td>
<td>Regulated Bus</td>
</tr>
<tr>
<td>OTHER DATA</td>
<td>Net Area Interchange</td>
</tr>
<tr>
<td></td>
<td>Area Transactions</td>
</tr>
</tbody>
</table>

**Note:**
ACRONYMS

ATC – Available Transfer Capability
CAP – Capacitor
EIA – Energy Information Act
ERAG – Eastern Interconnection Reliability Assessment Group
ERCOT – Electric Reliability Council of Texas
FPC – Federal Power Commission
IDEV – Input Device (PSS®E Dialog Input Device Selection Activity)
LTC – Load Tap Changing
MAPP – Mid-Continent Area Power Pool
MAIN – Mid-American Interpool Network
MBASE – Machine Base
MDWG – Model Development Working Group
MMWG – Multiregional Modeling Working Group
Mvar – Megavar
MW – Megawatt
NERC – North American Electric Reliability Corporation
PSS®E – Power System Simulator for Engineers
PTI – Power Technologies, Inc.
pu – Per-unit
RAWD – Raw Data
RDCH – Read Change (Command to read in and change data in PSS®E)
REAC – Reactor
SERC – Southeastern Electric Reliability Council
SPP – Southwest Power Pool, Inc.
STEP – SPP Transmission Expansion Plan
TWG – Transmission Working Group
WSCC – Western Systems Coordinating Council
ZSOURCE – Zero Impedance

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at www.spp.org.
See the “Glossary and Acronyms” link under “Training”
**MDWG Contact List**
The MDWG Contact List can be found on SPP's website, spp.org, under the documents section of the Model Development Working Group.

**SPP Model Release Guidelines**

**Steady-State and Short Circuit Models**
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If equivalized, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.

**System Dynamic Data Base and Dynamic Simulation Cases**
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.

**SPP Model Contact:**
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

**Request an SPP Map / Model**
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

**MDWG Case Type Set**
The current MDWG Case Type Set can be found on SPP's website, spp.org, under the documents section of the Model Development Working Group.

**Error Screening**
The following data error screening checks will be used to check case quality:
1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

Dynamics Data Submittal Requirements and Guidelines

Steady-State Modeling Requirements
1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.
3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.
4. In accordance with PTI PSS®E requirements, the Xsource value in the steady-state generator data record shall be as follows:
   a. Xsource = X''d for detailed synchronous machine modeling
   b. Xsource = X'd for non-detailed synchronous machine modeling
   c. Xsource = should be equal to locked rotor impedance for an induction machine
   d. Xsource = 1.0 per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E dynamic library models compatible with either representation are available. If a user model representing particular SVC and control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

Dynamic Modeling Requirements

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The PSS®E dynamic model types classified as detailed are GENROU, GENSAL, GENROE, GENSAE, and GENDCO. The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.
   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.
   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
   c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
   d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.
4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

**Dynamics Data Validation Requirements**

1. All dynamics modeling data shall be screened according to the SDDB data screening checks.

2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.

3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation.
checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).

2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.
Procedures for Submission of Dynamics Data to the MMWG Coordinator
Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template
Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.

The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another model of the same equipment group</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes for new model.</td>
<td>1. A DC exciter is replaced by a static exciter. 2. A classical machine model is replaced by a detailed model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all models of an existing unit</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
</tr>
<tr>
<td>Change bus number</td>
<td>No</td>
<td>No</td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
</tr>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
<td>Same requirements whether unit is at new or existing bus.</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Complete Set of Dynamics Data
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.
MMWG Deliverables

Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).
1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.
2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.
1. Steady-State Cases
   a. Steady-State RAWD case file
   b. Conversion IDEV files
2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case
4. Final reports
SECTION 2: STEADY-STATE MODELING

1. **Modeling Detail** – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. **Nominal Bus Voltage** – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. **Islanded Buses** – Islanded buses shall not be modeled.

4. **Generator Modeling of Loads** – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. **Zero Impedance Branches** – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using R=0.00000 + X=0.0001 and B=0.00000. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of R=0.0001 + X=0.002 and B=0.00000. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. **Impedance of Branches In Network Equivalents** – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. **Negative Branch Reactances** – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. ** Transformers** – Effective with Revision 28 of PSS®E, off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding. The measured impedance (resistive and inductive) between each pair of windings shall be specified: data entry options permit these to be entered in (1) per unit on system (100 MVA) base, (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage.
9. Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

10. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

11. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes. PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:
   a. Real-time operational auto or manual adjustment operation of the PST.
   b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
   c. Real-time operational MW flow limits (e.g. ±20 MW).
   d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
   e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
   f. Applicable long-term firm transmission service levels for the PST.

12. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

13. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled
explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

14. Out-of-Service Generator Modeling – Out-of-service generators should be modeled with a STATUS equal to zero.

15. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

17. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

18. Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

19. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

20. Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

21. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

22. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough
that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

23. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point and equipment status, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation.

24. HVDC – All HVDC transmission facilities must be represented with a sufficiently detailed model to simulate its expected behavior.

25. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

26. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it.
   (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)
2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.
3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during equivalencing.
4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.
5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.
6. Unrealistic tap changing transformer tap limits.
7. Radial system is very large.
8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.
10. Not solvable from flat start.
11. Fictitious regulation of buses.
12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Problems

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.
SECTION: PROCEDURES FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or −9999.
   c. Checks which report abnormal values
      i. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      ii. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      iii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      iv. Branches with extreme impedances or tap ratios [BRCH]. Suggested options are:
         a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
         b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
         c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.
d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.
e) High tap ratios.
f) Low tap ratios.
d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.
i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+99999) and PMIN (-99999) limits are present.
ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.
iii. Questionable voltage or flow controlling transformer parameters. [TPCH]
iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.
a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]
b. Read in the raw data file just created. [READ]
c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]
d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].
e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYS], and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)
a. Specify CONEC, CONET, and Compile files.
b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using “user dynamics”.
a. Read converted load flow [CASE].
b. Read in the dynamic data file [DYRE]
c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.
d. Check consistency of dynamic models [DYCH, option 1].
e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
   i. Warning messages for
      a) Generators in the load flow for which there is no active machine model.
      b) Models, usually of excitation systems or governors, initialized out of limits.
      c) The number of iterations required to initialize the initial-conditions steady-state.

   ii. A tabulation of conditions at each online machine
       a) Terminal voltage
       b) Exciter output voltage
       c) Real and reactive power output
       d) Power factor
       e) Machine angle in degrees
       f) Direct and quadrature axis currents on machine base.

   iii. A diagnosis of initial conditions, either
       a) “Initial conditions check OK”, or
       b) A listing of suspect initial conditions generally states whose time derivative is not “small” (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.

   iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

   f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN].
    Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
    a. Excessive overshoot
    b. Sustained oscillations
    c. High frequency noise (may be caused by using too long a simulation time step.)
    d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 "non-continuous" regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain
equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((-K) = (1 - 1/R)\), mechanical power to \((1 - 1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

### Compliance

1. **MDWG Model Development Procedure Manual**  
   Note: The latest document can be found on SPP.org

2. **MDWG Power flow, Short Circuit, and Dynamic model schedule and list**  
   Note: The latest document can be found on SPP.org

3. **Data Submittal Forms (This is a separate document)**  
   Note: The latest document is posted with every model set

4. **MDWG Procedure for late or no data submittal (FUTURE)**
SECTION: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#, 
From Area Name,
From Bus#, 
From Bus Name, 
From Bus kV,
To Region Name,
To Area#, 
To Area Name,
To Bus#, 
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI (pu),
BI (pu),
GJ (pu),
BJ (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area #,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area #,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS {0, 1},
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RMI1,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

- In Service Date,
- Out Service Date,
- Winding 1 Region Name,
- Winding 1 Area #,
- Winding 1 Area Name,
- Winding 1 Bus #,
- Winding 1 Bus Name,
- Winding 1 Bus kV,
- Winding 2 Region Name,
- Winding 2 Area #,
- Winding 2 Bus Name,
- Winding 2 Bus #,
- Winding 2 Bus kV,
- Winding 3 Region Name,
- Winding 3 Area #,
- Winding 3 Area Name,
- Winding 3 Bus #,
- Winding 3 Bus Name,
- Winding 3 Bus kV,
- CKT,
- CW,
- CZ,
- CM,
- MAG1,
- MAG2,
- NMETR(1,2,3),
- NAME,
- STATUS(0,1),
- Owner 1,
- Fraction 1,
- Owner 2,
- Fraction 2,
- Owner 3,
- Fraction 3,
- Owner 4,
- Fraction 4,
- R1-2,
- X1-2,
- SBase1-2,
- R2-3,
- X2-3,
- SBASE2-3,
- R3-1,
Three Winding Transformer Data Fields - continued
X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus #1(CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RMI1,
VMA1,
VM1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued

RM12,
VMA2,
VM12,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RM3,
VMA3,
VM3,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields
In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VScHD,
VCMOD (1.0),
RCOMP,
DELTI,
METER (R,I),
DCVMIN,
CCCITMX,
CCCACC,
IPR REGION NAME,
IPR AREA#, 
IPR AREA NAME,
IPR Bus#,
IPR BUS NAME,
IPR BUS kV,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#, 
ICR AREA NAME,
ICR BUS#,
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#, 
IFR AREA NAME,
IFR BUS#,
IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME, 
ITR BUS KV, 
IDR, 
XCAPR, 
IPI REGION NAME, 
IPI AREA#, 
IPI AREA NAME, 
IPI Bus#, 
IPI BUS NAME, 
IPI BUS Kv, 
NBI, 
GAMMX, 
GAMMN, 
RCI, 
XCI, 
EBASI, 
TRI, 
TAPI, 
TMXI, 
TMNI, 
STPI, 
ICI REGION NAME, 
ICI AREA#, 
ICI AREA NAME, 
ICI BUS#, 
ICI BUS NAME, 
ICI BUS KV, 
IFI REGION NAME, 
IFI AREA#, 
IFI AREA NAME, 
IFI BUS#, 
IFI BUS NAME, 
IFI BUS KV, 
ITI REGION NAME, 
ITI AREA#, 
ITI AREA NAME, 
ITI BUS#, 
ITI BUS NAME, 
ITI BUS KV, 
IDI, 
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements. 
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
### SECTION: APPENDIX II
### NUMBER RANGE ASSIGNMENTS FOR ERAG MMWG STEADY-STATE DATA

<table>
<thead>
<tr>
<th>Region</th>
<th>Bus Numbers</th>
<th>Area Numbers</th>
<th>Zone Numbers</th>
<th>Owner Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire System</td>
<td>100,000 - 899,999</td>
<td>100 to 899</td>
<td>100 to 1,899</td>
<td>100 to 1,199</td>
</tr>
<tr>
<td>NPCC</td>
<td>100,000 to 199,999</td>
<td>100 to 199</td>
<td>100 to 199 and 1,100 to 1,199</td>
<td>100 to 199</td>
</tr>
<tr>
<td>RFC</td>
<td>200,000 to 299,999</td>
<td>200 to 299</td>
<td>200 to 299 and 1,200 to 1,299 and 1,800 to 1,899</td>
<td>200 to 299</td>
</tr>
<tr>
<td>SERC</td>
<td>300,000 to 399,999</td>
<td>300 to 399</td>
<td>300 to 399 and 1,300 to 1,399</td>
<td>300 to 399</td>
</tr>
<tr>
<td>FRCC</td>
<td>400,000 - 499,999</td>
<td>400 to 499</td>
<td>400 to 499 and 1,400 to 1,499</td>
<td>400 to 499</td>
</tr>
<tr>
<td>SPP</td>
<td>500,000 to 599,999</td>
<td>500 to 599</td>
<td>500 to 599 and 1,500 to 1,599</td>
<td>500 to 599 and 800 to 899</td>
</tr>
<tr>
<td>MRO</td>
<td>600,000 to 699,999</td>
<td>600 to 699</td>
<td>600 to 699 and 1,600 to 1,699</td>
<td>600 to 699</td>
</tr>
<tr>
<td>ERCOT (future)</td>
<td>700,000 to 799,999</td>
<td>700 to 799</td>
<td>700 to 799 and 1,700 to 1,799</td>
<td>700 to 799</td>
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</tbody>
</table>

1. Area or zone number 1 is sometimes used as a default when the number is omitted by mistake. Its use to number an actual area should be avoided.
## SECTION: APPENDIX III
### UTILIZED IMPEDANCE CORRECTION TABLES

<table>
<thead>
<tr>
<th>Table Number</th>
<th>Tap or Angle</th>
<th>1 Factor</th>
<th>2 Factor</th>
<th>3 Factor</th>
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<tbody>
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<td>1</td>
<td>-60</td>
<td>0.358</td>
<td>-24.4</td>
<td>-12.4</td>
</tr>
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<td>-24.4</td>
<td>-12.4</td>
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<td>-24.4</td>
<td>-12.4</td>
</tr>
<tr>
<td>5</td>
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<td>-24.4</td>
<td>-12.4</td>
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<td>-12.4</td>
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<td>-24.4</td>
<td>-12.4</td>
</tr>
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<td>-12.4</td>
</tr>
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<td>411</td>
<td>FMPP</td>
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<td>412</td>
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</tr>
<tr>
<td>414</td>
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</tr>
<tr>
<td>415</td>
<td>TAL</td>
<td>City of Tallahassee</td>
</tr>
<tr>
<td>416</td>
<td>TECO</td>
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</tr>
<tr>
<td>417</td>
<td>FMP</td>
<td>FMPA / City of Vero Beach</td>
</tr>
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<td>418</td>
<td>NUG</td>
<td>Non-Utility Generators</td>
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<tr>
<td>419</td>
<td>RCU</td>
<td>Reedy Creek Energy Services, INC.</td>
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<tr>
<td>421</td>
<td>TCEC</td>
<td>Treasure Coast Energy Center</td>
</tr>
<tr>
<td>426</td>
<td>OSC</td>
<td>Osceola at Holopaw (PEF)</td>
</tr>
<tr>
<td>427</td>
<td>OLEANDER</td>
<td>Oleaner IPP at Brevard (FPL)</td>
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<tr>
<td>428</td>
<td>CALPINE</td>
<td>Calpine at Recker (TECO)</td>
</tr>
<tr>
<td>431</td>
<td>VAN</td>
<td>IPS Avon Park at Vandolah (PEF)</td>
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<td>433</td>
<td>HPS</td>
<td>Hardee Power Station (TECO)</td>
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<td>436</td>
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<td>Desoto Generation IPP at Whidden (FPL)</td>
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<td>438</td>
<td>IPP-REL</td>
<td>Reliant at Indian River (FMPP)</td>
</tr>
<tr>
<td>Area #</td>
<td>ID</td>
<td>System</td>
</tr>
<tr>
<td>--------</td>
<td>----</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>502</td>
<td>CELE</td>
<td>Central Louisiana Electric Company</td>
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<tr>
<td>503</td>
<td>LAFA</td>
<td>Lafayette Utilities</td>
</tr>
<tr>
<td>504</td>
<td>LEPA</td>
<td>Louisiana Energy and Power Authority</td>
</tr>
<tr>
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<td>ALEX</td>
<td>City of Alexandria</td>
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<tr>
<td>507</td>
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<td>Rayburn Country Electric Cooperative</td>
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<td>508</td>
<td>NTEC</td>
<td>North Texas Electric Cooperative</td>
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<tr>
<td>509</td>
<td>SRGT</td>
<td>Sam Rayburn G&amp;T</td>
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<td>ARHC</td>
<td>Arkansas Electric Cooperative</td>
</tr>
<tr>
<td>513</td>
<td>CLWL</td>
<td>City of Clarksdale</td>
</tr>
<tr>
<td>514</td>
<td>MEAM</td>
<td>Municipal Energy Agency of Mississippi</td>
</tr>
<tr>
<td>515</td>
<td>SWPA</td>
<td>Southwestern Power Administration</td>
</tr>
<tr>
<td>520</td>
<td>AEPW</td>
<td>American Electric Power</td>
</tr>
<tr>
<td>522</td>
<td>KAMO</td>
<td>Kamo Electric Cooperative</td>
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<td>525</td>
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<td>Western Farmers Electric Cooperative</td>
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<td>526</td>
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<td>Southwestern Public Service</td>
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<td>OMPA</td>
<td>Oklahoma Municipal Power Authority</td>
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<td>531</td>
<td>MIDW</td>
<td>Midwest Energy</td>
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<tr>
<td>534</td>
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<td>Sunflower Electric Cooperative</td>
</tr>
<tr>
<td>536</td>
<td>WERE</td>
<td>Westar</td>
</tr>
<tr>
<td>537</td>
<td>SIKE</td>
<td>City of Sikeston, Missouri</td>
</tr>
<tr>
<td>539</td>
<td>WEPL</td>
<td>Westplains Energy</td>
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<tr>
<td>540</td>
<td>MIPU</td>
<td>Missouri Public Service Company</td>
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<tr>
<td>541</td>
<td>KAPL</td>
<td>Kansas City Power and Light Company</td>
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<tr>
<td>542</td>
<td>KACY</td>
<td>Board of Public Utilities</td>
</tr>
<tr>
<td>544</td>
<td>EMDE</td>
<td>Empire District Electric Company</td>
</tr>
<tr>
<td>545</td>
<td>INDN</td>
<td>City of Independence</td>
</tr>
<tr>
<td>546</td>
<td>SPRM</td>
<td>City Utilities of Springfield</td>
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</table>
### MRO - Midwest Reliability Organization

<table>
<thead>
<tr>
<th>Area #</th>
<th>ID</th>
<th>System</th>
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</thead>
<tbody>
<tr>
<td>600</td>
<td>XEL</td>
<td>Xcel Energy North</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MUNI  Municipal data from Xcel Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MMPA  MMPA Municipal data from Xcel Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CMMPA  CMMPA Municipal data from Xcel Energy</td>
</tr>
<tr>
<td>608</td>
<td>MP</td>
<td>Minnesota Power &amp; Light</td>
</tr>
<tr>
<td>613</td>
<td>SMMPA</td>
<td>Southern Minnesota Municipal Power Association</td>
</tr>
<tr>
<td>615</td>
<td>GRE</td>
<td>Great River Energy</td>
</tr>
<tr>
<td>620</td>
<td>OTP</td>
<td>Otter Tail Power Company</td>
</tr>
<tr>
<td>627</td>
<td>ALTW</td>
<td>Alliant Energy West</td>
</tr>
<tr>
<td>633</td>
<td>MPW</td>
<td>Muscatine Power &amp; Water</td>
</tr>
<tr>
<td>635</td>
<td>MEC</td>
<td>MidAmerican Energy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CBPC  CBPC Municipal data from MEC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>RPGI  RPGI Municipal data from MEC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>IAMU  IAMU Municipal data from MEC</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MMEC  MMEC Municipal data from MEC (AMES,CFU, etc.)</td>
</tr>
<tr>
<td>640</td>
<td>NPPD</td>
<td>Nebraska Public Power District</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MEAN  Municipal Energy Agency of Nebraska (NPPD)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GRIS  Grand Island (NPPD)</td>
</tr>
<tr>
<td>645</td>
<td>OPPD</td>
<td>Omaha Public Power District</td>
</tr>
<tr>
<td>650</td>
<td>LES</td>
<td>Lincoln Electric System, NE</td>
</tr>
<tr>
<td>652</td>
<td>WAPA</td>
<td>Western Area Power Administration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MPC  Minnkota Power Cooperative, Inc.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BEPC  Basin Electric Power Cooperative</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NWPS  Northwestern Public Service</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MRES  Missouri River Energy Services</td>
</tr>
<tr>
<td>661</td>
<td>MDU</td>
<td>Montana-Dakota Utilities Co.</td>
</tr>
<tr>
<td>667</td>
<td>MHEB</td>
<td>Manitoba Hydro</td>
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<tr>
<td>672</td>
<td>SPC</td>
<td>Saskatchewan Power Co.</td>
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<tr>
<td>680</td>
<td>DPC</td>
<td>Dairyland Power Cooperative</td>
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<tr>
<td>694</td>
<td>ALTE</td>
<td>Alliant Energy East (ATC)</td>
</tr>
<tr>
<td>696</td>
<td>WPS</td>
<td>Wisconsin Public Service Corporation (ATC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CWP  Consolidated Water Power Company (ATC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MEWD  Marshfield Electric and Water Company (ATC)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MPU  Manitowoc Public Utilities (ATC)</td>
</tr>
<tr>
<td>697</td>
<td>MGE</td>
<td>Madison Gas and Electric Company (ATC)</td>
</tr>
<tr>
<td>698</td>
<td>UPPC</td>
<td>Upper Peninsula Power Company (ATC)</td>
</tr>
</tbody>
</table>

### ERCOT & WECC

<table>
<thead>
<tr>
<th>Area #</th>
<th>ID</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>700</td>
<td>ERCOT</td>
<td>Electric Reliability Council of Texas, Inc.</td>
</tr>
<tr>
<td>800</td>
<td>WECC</td>
<td>Western Electricity Coordinating Council</td>
</tr>
</tbody>
</table>
The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnectionwide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)</td>
<td>(If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</td>
<td>Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>a. Positive Sequence Data</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>b. Negative Sequence Data</td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td>5. Demand [LSE]</td>
<td>2. Mutual Line Impedance Data [TO]</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td>6. Wind Turbine Data [GO]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>3. Generating Units 14 [GO, RP (for future planned resources only)]</td>
<td>7. Photovoltaic systems [GO]</td>
<td></td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
<td></td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td>9. DC system models [TO]</td>
<td></td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide data in the same</td>
<td>10. Other information requested by the Planning Coordinator or Transmission Planner</td>
<td></td>
</tr>
</tbody>
</table>

13 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
manner as that required for aggregate Demand under item 2, above).

d. regulated bus* and voltage set point* (as typically provided by the TOP)

e. machine MVA base

f. generator step up transformer data (provide same data as that required for transformer under item 6, below)

g. generator type (hydro, wind, fossil, solar, nuclear, etc)

h. in-service status*

4. AC Transmission Line or Circuit [TO]

a. impedance parameters (positive sequence)

b. susceptance (line charging)

c. ratings (normal and emergency)*

d. in-service status*

5. DC Transmission systems [TO]

6. Transformer (voltage and phase-shifting) [TO]

a. nominal voltages of windings

b. impedance(s)

c. tap ratios (voltage or phase angle)*

d. minimum and maximum tap position limits

e. number of tap positions (for both the ULTC and NLTC)

f. regulated bus (for voltage regulating transformers)*

g. ratings (normal and emergency)*

h. in-service status*
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
**SECTION: APPENDIX VII**

**Modeling of Generator Parameters**

1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

**Modeling Process for Generator Parameters**

a. The Generator parameter $P_{\text{MAX}}$ shall be modeled as a gross seasonal maximum capability based on MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

b. Generating plant station service and auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All station service and auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus 15, corresponding to the voltage to which the auxiliary load is served. Model representations of auxiliary load connected to the generating unit bus (Figure VII-1), auxiliary load modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

---

15 Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the $P_{\text{gen}}$ of a unit with an amount corresponding to the plant auxiliary load.
c. Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

If generating plant station service and auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use “SS” in the Load ID field (Figure VII-4a). If there are more than one aggregated generating plant station service and auxiliary load, use “$n$” in the Load ID field to delineate the multiple aggregated loads.

If generating plant station service and auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant $P_{gen}$ may be less than $P_{max}$) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “$F_n$” in the Load ID field\(^ {16}\) to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “$V_n$” in the Load ID field\(^ {4}\) to designate variable load quantities that do vary with plant dispatch.

---

\(^{16}\) “$n$” represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
Modeling of Wind/Solar Renewable Resources $P_{\text{GEN}}$

- Light load models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP coincident off-peak hour corresponding to the season of the Light Load case, not to exceed each facility’s firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

- Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility’s firm service amount.

- To the maximum extent possible, historical data will be used to determine the renewable dispatch. The following table will be used for default renewable dispatch percentage in lieu of resources that do not have five years of historical data.

<table>
<thead>
<tr>
<th>States</th>
<th>Winter %</th>
<th>Spring %</th>
<th>Light Load %</th>
<th>Summer %</th>
<th>Fall %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iowa</td>
<td>66.2%</td>
<td>26.1%</td>
<td>26.5%</td>
<td>39.5%</td>
<td>35.9%</td>
</tr>
<tr>
<td>South Dakota</td>
<td>50.7%</td>
<td>8.2%</td>
<td>44.6%</td>
<td>17.5%</td>
<td>29.7%</td>
</tr>
<tr>
<td>Oklahoma</td>
<td>30.5%</td>
<td>45.7%</td>
<td>46.3%</td>
<td>35.1%</td>
<td>53.6%</td>
</tr>
<tr>
<td>Kansas</td>
<td>37.9%</td>
<td>29.3%</td>
<td>25.3%</td>
<td>36.6%</td>
<td>50.3%</td>
</tr>
<tr>
<td>Texas</td>
<td>41.0%</td>
<td>45.1%</td>
<td>53.0%</td>
<td>37.3%</td>
<td>61.5%</td>
</tr>
<tr>
<td>North Dakota</td>
<td>51.8%</td>
<td>26.2%</td>
<td>10.9%</td>
<td>21.3%</td>
<td>9.1%</td>
</tr>
<tr>
<td>New Mexico</td>
<td>40.7%</td>
<td>55.0%</td>
<td>44.0%</td>
<td>30.3%</td>
<td>53.2%</td>
</tr>
<tr>
<td>Nebraska</td>
<td>51.6%</td>
<td>16.1%</td>
<td>20.1%</td>
<td>6.2%</td>
<td>40.2%</td>
</tr>
<tr>
<td>Missouri</td>
<td>59.5%</td>
<td>34.8%</td>
<td>28.9%</td>
<td>7.6%</td>
<td>39.1%</td>
</tr>
</tbody>
</table>

Default Renewable Firm Service Dispatch in lieu of Historical Data \(^2\)

- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of each SPP MDWG model build.

- When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

- Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

\[^1\] SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

\[^2\] This data is updated annually via the ITP Renewable Resource Replacement Data Methodology process.
of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed, for comparable data if historical data is unavailable.

Data Exemption Process
MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the "Exemption Form" and send it via e-mail to "Engineering Modeling" containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.**
**Effective date of section 2 is July 1, 2016.**
**Effective date of section 4 is July 1, 2016.**
SECTION: APPENDIX VIII - BALANCING AND TRANSACTIONS

Background

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of buses representing a model area. While typically analogous to a Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP loads and induction machine loads to be assigned to model areas that may be different than the buses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

19 The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

20 Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).

21 ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (P_{gen}) of each non-slab generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from
imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the [MDWG Data Submittal Workbook](#). Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models,
external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:

a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e., whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e., scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e., whole MW).

5. Ensure that source transaction have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

**Data Owner A**

![Diagram showing inter-area transfer](image)

**Data Owner B**

**Source**

**Sink**

---

**Inter-area Bilateral transaction description**

Data Owner A exports MW to Data Owner B

Data Owner B imports MW from Data Owner A

**Transaction accounting in Data Submittal Workbook**

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>20xx Series</th>
<th>MDWG</th>
<th>Model</th>
<th>18G</th>
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<td>1</td>
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<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
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<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>2</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Figure 3. Example of inter-area transfer (transaction).*
6. Complete the following required Data Submittal Workbook EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate Data Submittal WorkbookEDST field.

8. The following Data Submittal WorkbookEDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.
<table>
<thead>
<tr>
<th>DATE OR VERSION NUMBER</th>
<th>AUTHOR</th>
<th>CHANGE DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
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<td>SPP Engineering Modeling</td>
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<tr>
<td>2018 v1.2</td>
<td>SPP Engineering Modeling</td>
<td>Updated Introduction &amp; Dynamic modeling section</td>
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, data owners, equipment, and data submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.
Scope of Applicability

It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1)\(^1\), and the provisions of the SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

Applicable Data Owners

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

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\(^1\) The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.

\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.

Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.

Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.
Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise,

5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Equivalencing is a general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.
8 Sixth Revised Volume No.1, Attachment AI, Part II-1.
9 Sixth Revised Volume No.1, Attachment AI, Part II-2.
10 Sixth Revised Volume No.1, Part III-30.
11 Sixth Revised Volume No.1, Part III-31.
consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted. Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule ("schedule") jointly developed by the Transmission Planners and Planning Coordinator.

Accountability

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- Appropriate lead times. Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes. In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
**General Data Reporting Responsibilities**

The SPP data reporting entities are responsible for the following categories of system modeling data:

1. Steady-State
2. Short Circuit
3. Dynamics

Steady-State models are developed for an annual series of SPP cases, including an annual series of ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by SPP Regional Tariff and Planning Criteria.

Short Circuit models are developed annually using a subset of the Reliability Steady-State models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

The Dynamics Model is also updated annually with current generator unit information. Steady-State models are used in conjunction with dynamic data to run dynamic simulation.

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.
Entities in the SPP Planning Coordinator region that are not members of the SPP but required to submit data (i.e. IPPs, Municipalities) will submit data directly to the Transmission Owner or Balancing Authority in which their system resides. Upon review (i.e. data accuracy, quality) by the Transmission Owner or Balancing Authority the data will then be provided to the SPP during the annual MDWG case type update process. The data submitted will be in the standard PTI format as specified in the MDWG Model Development procedure manual. All non-SPP members that are responsible for submitting this data should directly coordinate with the Transmission Owner or Balancing Authority on timing for sending data, as well as any special requirements in data formatting.

In an effort to determine who is collecting/submitting data for whom, all NERC registered entities within the SPP PC footprint (MOD-032-1: applicable to BA, GO, LSE, RP, TO, TP, and TSP) shall fill out the data coordination workbook to notify SPP if data is being submitted directly to SPP or through some other entity(ies) on behalf of your company. Likewise, SPP shall be notified if your company is submitting data on behalf of another entity(ies).

**Confidentiality and Proprietaryship**

The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

**Schedule**

As with all schedules, the meeting of deadlines is most critical. All system representatives must familiarize themselves with the schedule well in advance of all deadlines. This will alleviate any problems with the timing of data submittal and data reviews. The schedule for model development will be sent with the first data request as well as posted on the SPP corporate website, www.spp.org.

**Steady-State and Short Circuit Model Development**

The MDWG Steady-State and Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the EDST. MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Steady-State and Short Circuit Models are published according to the approved schedule.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set.
The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.

**Dynamic Model Development**

**Introduction**

The MDWG Dynamic Models include full MMWG cases and machine reduced cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model Update is used to support SPP reliability studies and ERAG MMWG Dynamic model requirements. It is important for all generating entities that interconnect to the SPP transmission to support the Regional Transmission Organization with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic Model Format is PSS®E dynamics DYRE and RAWD formats.

The Dynamics Model data includes:

1. Steady-State models
2. Dynamics model data in Siemens PTI PSS®E DYRE format
3. User written model source and object code (includes wind farms)
4. ERAG MMWG System Dynamics Database (SDDB)
5. SDDB data update worksheet

SPP MDWG Dynamic Models are published according to the schedule in Section 15 B.
MODEL DEVELOPMENT ENGINEERING DATA SUBMISSION TOOL

Data Preparation

The following section describes important items that must be followed in the development of a steady-state model in preparing the data for publishing new models or updating existing models.

1. The data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

2. MOD data should be kept current for each pass during the MDWG model build.

3. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

4.1 Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).

5.2 Generator Data – Required generator data that is not otherwise captured in the models.

6.3 SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.

7.4 Load Mapping Details – Identify loads not served by native Control model Areas.

8.5 Data Dictionary Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.

9.6 Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.

4.7 Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.

Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of Winter: 12/1/2017 – 3/31/2018; yyyy+1 = 2018

Steady-State and Short Circuit Data Format

PSS®E and MOD Users

The transmission modeling software approved by the SPP membership for performing planning.
and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

Dynamic Data Format

PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyr file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

Non-PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

NERC maintains a list of acceptable dynamic models on the NERC website for reference by the GO. Only NERC acceptable dynamic models from the latest approved list shall be provided the applicable TPs and to SPP, as PC, for dynamic model building purposes. The acceptable dynamic model list can be found on the NERC SAMS website→SAMS Reference Materials→NERC Acceptable Model List.

Dynamic models that are considered unacceptable by NERC shall be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes
4. Documentation, including Block Diagram, in .pdf or .docx format

A written commitment to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions.
regarding the data format.

**Responsible Entities**

Data owners are responsible for providing the data necessary to model their assets to its Transmission Planner(s) and Planning Coordinator(s) as described in this document. Data owners and their respective data submission responsibilities are noted in the NERC standard MOD-032-1.

1. Generator Owners (GO) and Resource Planners (RP) are responsible for submitting modeling data for their existing and future generating facilities respectively.
2. Load Serving Entities (LSE) are responsible for submitting modeling data for their existing and future load corresponding to the case types developed.
3. Transmission Owners (TO) are responsible for submitting modeling data for their existing and future transmission facilities.
4. The Planning Coordinator or Transmission Planner can request other information necessary for modeling purposes from the BA, GO, LSE, TO, or TSP.

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**Typical Annual Models**

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the **Annual Models** table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.
The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The **schedule** for submission to data and list of MDWG models [case types](#) can be found on the SPP corporate website, www.spp.org.

Transactions modeled in all base cases should be limited to expected firm schedules and should not include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

**Load Forecast**

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be Non-Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences an On-peak demand for a particular season, might not be the same hour that SPP, as a region, experiences an On-peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand. DSM consists of controllable and non-controllable systems. Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will
be reduced during On-peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during On-peak hours without manual intervention. Distributed Energy Resources are power resources on the distribution system that can be aggregated together to provide power to meet Demand. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the SPP Open Access Transmission Tariff (OATT) shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed agreement, or are in the process of finalizing a signed agreement should be included in the Data Submitter’s load forecast. SPP may reject any MOD projects or PSSE idev projects that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Non-coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

**On-Peak Off-Peak Models**

Seasonal On-Peak models developed by SPP include: Summer Peak, Winter Peak, Spring Peak, and Fall Peak. These four seasonal On-Peak models are built to represent the anticipated coincident seasonal peaks based on each individual Data Owner/Data Submitter’s respective seasonal On-Peak load. Data Owner/Data Submitter’s On-Peak load may not be coincident with the instance of the SPP Balancing Authority coincident On-Peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models. They include a Spring Light Load condition and a Summer Shoulder condition.

The Spring Light Load Off-Peak model is developed with the intent to capture each individual Data Owner/Data Submitter’s system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is defined to be 70% - 85% of the total Summer On-Peak load level, measured within each individual Data Owner/Data Submitter’s transmission system. It represents the average daily summer loading during the summer season.

Seasonal peak models developed by SPP include: Summer Peak, Winter Peak, Spring Peak, and Fall Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident with the SPP Balancing Authority coincident peak.

In addition to the seasonal peak models, SPP develops two off-peak models. They include: a Light

Commented [MO1]: Go through manual and replace peak with appropriate On/Off-Peak term.

Formatted: Highlight
Load condition and a Summer Shoulder condition.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder model, also known as the seasonal on-peak average model is defined to be 70% - 85% of the total Summer Peak load level depending on the Data Owner/Data Submitter system.

Spring Peak (G): April 1st through May 31st
Summer Peak (S): June 1st through September 30th
Fall Peak (F): October 1st through November 30th
Winter Peak (W): December 1st through March 31st
Light Load (L): April 1st through May 31st
Shoulder (SH): 70% - 85% of Summer Peak model

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.

**Area Summary Report**

The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. A renewable resource must be used then approval must be given by the MDWG.

5. An entity's area slack machine shall be modeled within the entity’s model area.

3.6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation and transactions must balance in the model area without a slack machine.

4.7. The case year and season should be entered in the appropriate locations in chronological order.

5.8. The current system official load forecast should be entered as net load (Item 6).

6.9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.

7.10. Load equals net load minus estimated losses (Item 4).

8.11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

9.12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**

Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed.

This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**

Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:
1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The “from bus,” “to bus,” and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance data shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be divided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each SPP member shall rate transmission circuits in accordance with the SPP Planning Criteria (Section 7.2). This criterion calls for each member to compute, at a minimum, summer and winter seasonal ratings for each circuit element. Each Base Case (Network) and Project branch, two-winding and three-winding transformer must have a specified rate A (normal) and rate B (long-term emergency) for spring, summer, fall, and winter. The ratings data format is in the MOD Procedure Manual.

6. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

7. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the SPP Regional Tariff. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.
8. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

9. Transformer connection codes12 and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc…).

**NOTE:** When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be

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12 Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

1. For generator regulated buses, a desired voltage magnitude will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.

Load Data

Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats.
The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The Non-Scalable Loads will be identified in the Non-Scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the EDST.

**Generator Data**

Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and Mbase limits per testing requirements in SPP Planning Criteria 7.1.1. Generator MW shall be set to "gross" level with auxiliary load modeled explicitly. Qmax and Qmin values in the models should be based on unit test data. Intermittent resources (e.g., wind and run-of-river hydro) should not normally be dispatched beyond their net capability as established by SPP Planning Criteria 7.1 for the summer and shoulder cases. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, **this complex impedance must be set equal to the sub unsaturated transient impedance for those generators modeled by sub transient level machine models**, and to transient impedance for those modeled by classical or transient level models. Machine Base (MBASE) and Zero Impedance (ZSOURCE) values for the steady-state models must match dynamic data. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X''di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.

**Shortfall Guidance Process**

A shortfall is defined as an instance of insufficient firm resource to supply firm load. Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.
2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   a. The in-service date shall be based on the expected in-service date of the GI study.
b. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).

c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of exploratory generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

Remote Generation Modeling

Purpose
This procedure assures that members adhere to a uniform process when modeling remote generation in SPP.

Modeling Process
If a member acquires remote generation outside their Control Area (steady-state model numbered area), the following modeling process should be followed:
1. All buses should be assigned numbers that are in the host’s control area bus number range.
2. Area Number/Name should be the host’s control area number.
3. Zone Number/Name should be in the host’s control area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where remote generation is located to the generation owner control area. If the remote generation is owned by multiple owners, then multiple transactions should be modeled.

Steady-State Data Check List
The steady-state data check list should be used as an aid for ensuring good model data. As the data and preliminary runs are reviewed for each model, the items should be checked off. A copy of this form can be found in Section 7.

Facilities Transferred to SPP’s Functional Control
The SPP FERC "Docket No. RT04-01-00 Volume 1", In the July 2 Order, the Commission: ...(7) ordered that SPP file a list of all transmission facilities that will be transferred to its operational control and revise the Operational Authority White Paper ("OA White Paper") or Membership Agreement, or provide some other binding document, to reflect SPP’s clear authority to exercise day-to-day control over the appropriate transmission facilities within its footprint...

Attachment AI to the SPP Regional Tariff contains the criteria for inclusion of facilities that are considered "Facilities Transferred to SPP’s Functional Control". Transmission facilities meeting the definition set forth in Attachment AI must be included in the SPP MDWG Steady-State Models.

Owner Data and Line Mileage Data (SAS-70 Control)

Per SAS-70 requirements (i.e. – Loss calculations) SPP Loss models must be updated every June and October with current Owner Data and Line Mileage data. To meet the SAS-70 requirement the SPP models must include owner data and line-mileage data. SPP Staff will obtain this data from the MOD Base Case and Projects; therefore; it is important that Members keep the data current in MOD.

Zone Range Assignments

SPP Area

Refer to the most current SPP Area Zone Assignments.

MMWG Region

<table>
<thead>
<tr>
<th>Region</th>
<th>Bus Numbers</th>
<th>Area Number</th>
<th>Zone Number</th>
<th>Owner Numbers</th>
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<tr>
<td>Entire System</td>
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<td>100 to 899</td>
<td>100 to 1,899</td>
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<td>700 to 799</td>
<td>700 to 799 and 1,700 to 1,799</td>
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</tr>
</tbody>
</table>
Data Transmittal

Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- GlobalScape
2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the "SPP MDWG File Sharing Site", GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors can change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).
4. **Network**

Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**

The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**

   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**

   Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

   Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

   The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

   Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A. for guidelines of typical transmission line or transformer impedance data.
b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

---

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. \( Q_T \) --- \( MAX = \) one-half of MW rating

ii. \( Q_B \) --- \( MIN = \) negative one-third of MW rating

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent...
representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).

Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI, IDEV format file to perform the RDCH operation. **This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.**

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.
The most current update to the models will always be posted on the SPP file sharing site.

*Program Operation*

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

**PTI-PSS®E Data Format**

Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a **comma** (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is **added** to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The **modification** of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data for that bus will be removed (e.g., branches, transformers, generators, and loads). **The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified.** Data currently in the model is used as the default value for data fields not specified in the format.
**Steady-State Solution**

The steady-state solution will have "Area interchange control" with the "Tie Line and Loads" option selected to meet ERAG MMWG model building requirements.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area's number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

**No Transaction Needed**
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

**Transaction Needed**
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.
TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data. The sequence data is comprised of positive, zero, and negative sequence data. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For GSUs that are not retired with the associated generator, the appropriate status should be reflected in the model in order to produce accurate short circuit results.

*Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).* The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.
**SPP Data**

**System Abbreviations & Area Number Assignments**
System Abbreviations & Area Number Assignments can be found on SPP's website, spp.org, under the documents section of the Model Development Working Group.

**SPP Members**
The SPP Members are identified on the SPP Website. See the "Members" link under "About SPP" on www.SPP.org.
## FORMS – Area Summary Report

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<thead>
<tr>
<th>CASE</th>
<th>POWER FLOW DATA AREA SUMMARY REPORT</th>
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</thead>
<tbody>
<tr>
<td>1. Generation</td>
<td>Purchases (-)/Sales (+)</td>
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<td>To/From Area Name</td>
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<td>2. Total Interchange</td>
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<td>3. Net Power (1-2)</td>
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<td>4. Load</td>
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<td>5. Losses</td>
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<td>6. Net Load (4+5)</td>
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<td>7. Slack Bus Generation</td>
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<td>8. Slack Bus Number &amp; Name</td>
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**Note:**
### FORMS – Steady-State Data Checklist

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<th>POWER FLOW DATA CHECKLIST</th>
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<td>Reactive Load</td>
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<td>Generation - Dispatch/Net</td>
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**Note:**

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<th>Prepared By:</th>
<th>Telephone Number:</th>
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</table>
ACRONYMS

ATC – Available Transfer Capability
CAP – Capacitor
EIA – Energy Information Act
ERAG – Eastern Interconnection Reliability Assessment Group
ERCOT – Electric Reliability Council of Texas
FPC – Federal Power Commission
IDEV – Input Device (PSS®E Dialog Input Device Selection Activity)
LTC – Load Tap Changing
MAPP – Mid-Continent Area Power Pool
MAIN – Mid-American Interpool Network
MBASE – Machine Base
MDWG – Model Development Working Group
MMWG – Multiregional Modeling Working Group
Mvar – Megavar
MW – Megawatt
NERC – North American Electric Reliability Corporation
PSS®E – Power System Simulator for Engineers
PTI – Power Technologies, Inc.
pu – Per-unit
RAWD – Raw Data
RDCH – Read Change (Command to read in and change data in PSS®E)
REAC – Reactor
SERC – Southeastern Electric Reliability Council
SPP – Southwest Power Pool, Inc.
STEP – SPP Transmission Expansion Plan
TWG – Transmission Working Group
WSCC – Western Systems Coordinating Council
ZSOURCE – Zero Impedance

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at www.spp.org.
See the “Glossary and Acronyms” link under “Training”
MDWG Contact List
The MDWG Contact List can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

SPP Model Release Guidelines

Steady-State and Short Circuit Models
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If equalized, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.

System Dynamic Data Base and Dynamic Simulation Cases
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.

SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Error Screening
The following data error screening checks will be used to check case quality:
1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

Dynamics Data Submittal Requirements and Guidelines

Steady-State Modeling Requirements

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.

2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.
4. In accordance with PTI PSS®E requirements, the Xsource value in the steady-state generator data record shall be as follows:
   a. Xsource = X''d for detailed synchronous machine modeling
   b. Xsource = X'd for non-detailed synchronous machine modeling
   c. Xsource = should be equal to locked rotor impedance for an induction machine
   d. Xsource = 1.0 per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E dynamic library models compatible with either representation are available. If a user model representing particular SVC and control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

**Dynamic Modeling Requirements**

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The PSS®E dynamic model types classified as detailed are GENROU, GENSAL, GENROE, GENSAE, and GENDCO. The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.

The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.

The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
   c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
   d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.
4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

   Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

**Dynamics Data Validation Requirements**

1. All dynamics modeling data shall be screened according to the SDDB data screening checks.

2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.

3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation.
checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).

2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.
Procedures for Submission of Dynamics Data to the MMWG Coordinator

Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template

Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready. The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
</tbody>
</table>
| Replace a model with another model of the same equipment group | Bus name, unit ID, model name for deleted model.                                  | Yes for new model           | 1. A DC exciter is replaced by a static exciter.  
2. A classical machine model is replaced by a detailed model. |
| Change bus name and/or unit ID for all models of an existing unit | Old and new names; old and new unit IDs                                        | No                          | Maintain the same name and unit ID and the model data will follow automatically. |
| Change bus number                      | No                                                                               | No                          | Maintain the same name and unit ID and the model data will follow automatically. |
| Add dynamic models for a new generating unit | Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type | Yes                         | Same requirements whether unit is at new or existing bus.   |
| Remove a unit and all associated models | Bus name, unit ID                                                               | No                          |                                                           |

Complete Set of Dynamics Data

The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.
MMWG Deliverables

Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   a. Initialized steady state and regional contingency cases.
   b. Conversion IDEV files

2. Dynamics Cases
   a. Dynamics case input data, output files and instructions including:
      a. Dynamics input data in DYRE format
      b. FLECS code for user defined models
      c. Load conversion CONL file sorted by area
      d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports
SECTION 2: STEADY-STATE MODELING

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity. If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using $R=0.00000 + X=0.0001$ and $B=0.00000$. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of $R=0.0001 + X=0.002$ and $B=0.00000$. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – Effective with Revision 28 of PSS®E, off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding. The measured impedance (resistive and inductive) between each pair of windings shall be specified: data entry options permit these to be entered in (1) per unit on system (100 MVA) base, (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage.
9. Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 3 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

10. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

11. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes. PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:
   a. Real-time operational auto or manual adjustment operation of the PST.
   b. Real-time operational average MW flow for a particular season (e.g., average hourly MW flow is +18MW [directional based] during the Summer On-Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
   c. Real-time operational MW flow limits (e.g., ±20 MW).
   d. Real-time operational phase shift angle range (e.g., -52.9° to 31.4°).
   e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
   f. Applicable long-term firm transmission service levels for the PST.

12. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

13. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. When modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled...
explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

14. Out-of-Service Generator Modeling – Out-of-service generators should be modeled with a STATUS equal to zero.

15. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and (QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step-up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

17. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

18. Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

19. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit, or below 0.90 per unit should be avoided.

20. Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

21. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

22. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g., SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough
that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

23. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point and equipment status, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation.

24. HVDC – All HVDC transmission facilities must be represented with a sufficiently detailed model to simulate its expected behavior.

25. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

26. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it.  
(Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during equivalencing.

4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. Fictitious regulation of buses.

12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.
14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.
15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Problems

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.
SECTION: PROCEDURES FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or -9999.
   c. Checks which report abnormal values
      i. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      ii. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      iii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      iv. Branches with extreme impedances or tap ratios [BRCH]. Suggested options are:
         a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
         b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
         c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.
d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit "carriage return" for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in "islands" not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]

c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].

e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)

a. Specify CONEC, CONET, and COMPILE files.

b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using "user dynamics".

a. Read converted load flow [CASE].

b. Read in the dynamic data file [DYRE]

c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.

d. Check consistency of dynamic models [DYCH, option 1].
e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
   i. Warning messages for
      a) Generators in the load flow for which there is no active machine model.
      b) Models, usually of excitation systems or governors, initialized out of limits.
      c) The number of iterations required to initialize the initial-conditions steady-state.

ii. A tabulation of conditions at each online machine
   a) Terminal voltage
   b) Exciter output voltage
   c) Real and reactive power output
   d) Power factor
   e) Machine angle in degrees
   f) Direct and quadrature axis currents on machine base.

iii. A diagnosis of initial conditions, either
   a) “Initial conditions check OK”, or
   b) A listing of suspect initial conditions generally states whose time derivative is not “small” (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.

iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain
equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((-K) = (-1/R)\), mechanical power to \((1-1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Compliance

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#, 
From Area Name,
From Bus#, 
From Bus Name,
From Bus kV,
To Region Name,
To Area#, 
To Area Name,
To Bus#, 
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI (pu),
BI (pu),
GJ (pu),
BJ (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM1,
VMA1,
VM1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#, 
Winding 1 Area Name,
Winding 1 Bus#, 
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#, 
Winding 2 Area Name,
Winding 2 Bus#, 
Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#, 
Winding 3 Area Name,
Winding 3 Bus#, 
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBase2-3,
R3-1,
Three Winding Transformer Data Fields - continued
X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus #(CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RM11,
VMA1,
VM11,
NTP 1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued
RM12,
VMA2,
VM12,
NTP 2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RM13,
VMA3,
VM13,
NTP 3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields
In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (R,I),
DCVMIN,
CCCTIMX,
CCCATM,
IP R REGION NAME,
IP R AREA#, IP R AREA NAME,
IP R BUS#, IP R BUS NAME,
IP R BUS kV,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#, ICR AREA NAME,
ICR BUS#, ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#, IFR AREA NAME,
IFR BUS#, IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields
ITF AREA NAME,
ITR BUS #,
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAPR,
IP1 REGION NAME,
IP1 AREA #,
IP1 AREA NAME,
IP1 Bus #,
IP1 BUS NAME,
IP1 BUS Kv,
NBI,
GAMMX,
GAMMN,
RCI,
XCI,
EBASI,
TR1,
TAPI,
TMXI,
TMNI,
STPI,
ICI REGION NAME,
ICI AREA #,
ICI AREA NAME,
ICI BUS #,
ICI BUS NAME,
ICI BUS Kv,
IFI REGION NAME,
IFI AREA #,
IFI AREA NAME,
IFI BUS #,
IFI BUS NAME,
IFI BUS Kv,
ITI REGION NAME,
ITI AREA #,
ITI AREA NAME,
ITI BUS #,
ITI BUS NAME,
ITI BUS Kv,
IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
## SECTION: APPENDIX II
### NUMBER RANGE ASSIGNMENTS FOR ERAG MMWG STEADY-STATE DATA

<table>
<thead>
<tr>
<th>Region</th>
<th>Bus Numbers</th>
<th>Area Numbers</th>
<th>Zone Numbers</th>
<th>Owner Numbers</th>
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</thead>
<tbody>
<tr>
<td>Entire System</td>
<td>100,000 – 899,999</td>
<td>100 to 899</td>
<td>100 to 1,899</td>
<td>100 to 1,199</td>
</tr>
<tr>
<td>NPCC</td>
<td>100,000 to 199,999</td>
<td>100 to 199</td>
<td>100 to 199 and 1,100 to 1,199</td>
<td>100 to 199</td>
</tr>
<tr>
<td>RFC</td>
<td>200,000 to 299,999</td>
<td>200 to 299</td>
<td>200 to 299 and 1,200 to 1,299 and 1,800 to 1,899</td>
<td>200 to 299</td>
</tr>
<tr>
<td>SERC</td>
<td>300,000 to 399,999</td>
<td>300 to 399</td>
<td>300 to 399 and 1,300 to 1,399</td>
<td>300 to 399</td>
</tr>
<tr>
<td>FRCC</td>
<td>400,000 – 499,999</td>
<td>400 to 499</td>
<td>400 to 499 and 1,400 to 1,499</td>
<td>400 to 499</td>
</tr>
<tr>
<td>SPP</td>
<td>500,000 to 599,999</td>
<td>500 to 599</td>
<td>500 to 599 and 1,500 to 1,599</td>
<td>500 to 599 and 800 to 899</td>
</tr>
<tr>
<td>MRO</td>
<td>600,000 to 699,999</td>
<td>600 to 699</td>
<td>600 to 699 and 1,600 to 1,699</td>
<td>600 to 699</td>
</tr>
<tr>
<td>ERCOT (future)</td>
<td>700,000 to 799,999</td>
<td>700 to 799</td>
<td>700 to 799 and 1,700 to 1,799</td>
<td>700 to 799</td>
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</tbody>
</table>

1 Area or zone number 1 is sometimes used as a default when the number is omitted by mistake. Its use to number an actual area should be avoided.
# SECTION: APPENDIX III
## UTILIZED IMPEDANCE CORRECTION TABLES

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<th>Table Number</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
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<th>Factor</th>
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<th>Factor</th>
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The table continues with more entries for each column.
## SECTION: APPENDIX IV

**UTILIZED DC LINES**

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SECTION: APPENDIX V  
SYSTEM CODES FOR USE IN ERAG MMWG  
STEADY-STATE DATA

**NPCC – Northeast Power Coordination Council**

<table>
<thead>
<tr>
<th>Area #</th>
<th>ID</th>
<th>System</th>
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<tbody>
<tr>
<td>101</td>
<td>ISO-NE</td>
<td>ISO New England</td>
</tr>
<tr>
<td>102</td>
<td>NYISO</td>
<td>New York ISO</td>
</tr>
<tr>
<td>103</td>
<td>IESO</td>
<td>Independent Electric System Operator</td>
</tr>
<tr>
<td>104</td>
<td>TE</td>
<td>TransEnergie</td>
</tr>
<tr>
<td>105</td>
<td>NB</td>
<td>New Brunswick Power</td>
</tr>
<tr>
<td>106</td>
<td>NS</td>
<td>Nova Scotia Power</td>
</tr>
<tr>
<td>107</td>
<td>CORNWALL</td>
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</table>

**RFC – Reliability First Corporation**

<table>
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</thead>
<tbody>
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<td>201</td>
<td>AP</td>
<td>Allegheny Power</td>
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<tr>
<td>202</td>
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<td>FirstEnergy</td>
</tr>
<tr>
<td>205</td>
<td>AEP</td>
<td>American Electric Power</td>
</tr>
<tr>
<td>206</td>
<td>OVEC</td>
<td>Ohio Valley Electric Corporation</td>
</tr>
<tr>
<td>207</td>
<td>HE</td>
<td>Hoosier Energy Rural Electric Cooperative, Inc.</td>
</tr>
<tr>
<td>208</td>
<td>DEM</td>
<td>Duke Energy Midwest</td>
</tr>
<tr>
<td>209</td>
<td>DAY</td>
<td>Dayton Power &amp; Light Company</td>
</tr>
<tr>
<td>210</td>
<td>SIGE</td>
<td>Southern Indiana Gas &amp; Electric Company</td>
</tr>
<tr>
<td>215</td>
<td>DLCO</td>
<td>Duquesne Light Company</td>
</tr>
<tr>
<td>216</td>
<td>IPL</td>
<td>Indianapolis Power &amp; Light Company</td>
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<td>NIPS</td>
<td>Northern Indiana Public Service Company</td>
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<tr>
<td>218</td>
<td>METC</td>
<td>Michigan Electric Transmission Co., LLC</td>
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<td>219</td>
<td>ITCT</td>
<td>International Transmission Company</td>
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<td>220</td>
<td>IPRV</td>
<td>Illinois Power- Riverside Plant</td>
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<tr>
<td>222</td>
<td>CE</td>
<td>Commonwealth Edison</td>
</tr>
<tr>
<td>225</td>
<td>PJM</td>
<td>PJM 500 kV System</td>
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<td>226</td>
<td>PENELEC</td>
<td>Pennsylvania Electric Company</td>
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<td>Jersey Central Power &amp; Light Company</td>
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<td>PPL Electric Utilities</td>
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<td>Atlantic Electric</td>
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<td>D&amp;P&amp;L</td>
<td>Delmarva Power &amp; Light Company</td>
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<td>UGI</td>
<td>UGE Utilities, Inc.</td>
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<td>Rockland Electric Company</td>
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<td>WEC</td>
<td>Wisconsin Electric Power Company (ATC)</td>
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SERC – SERC Reliability Corporation

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### MRO – Midwest Reliability Organization

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### ERCOT & WECC

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The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnectionwide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

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<th>steady-state (Items marked with an asterisk indicate data that vary with system operating state or conditions. These items may have different data provided for different modeling scenarios)</th>
<th>dynamics (If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</th>
<th>short circuit</th>
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<td>2. Aggregate Demand13 [LSE] a. real and reactive power* b. in-service status*</td>
<td>2. Excitation System [GO, RP( for future planned resources only)]</td>
<td>2. Mutual Line Impedance Data [TO]</td>
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<tr>
<td>3. Generating Units14 [GO, RP (for future planned resources only)] a. real power capabilities - gross maximum and minimum values b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above c. station service auxiliary load for normal plant configuration (provide data in the same</td>
<td>3. Governor [GO, RP( for future planned resources only)]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
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<td>4. Power System Stabilizer [GO, RP( for future planned resources only)]</td>
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<td>5. Demand [LSE]</td>
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<td>6. Wind Turbine Data [GO]</td>
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<td></td>
<td>7. Photovoltaic systems [GO]</td>
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<tr>
<td></td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
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<td>9. DC system models [TO]</td>
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<td>10. Other information requested by the Planning Coordinator or Transmission Planner</td>
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<th>steady-state (Items marked with an asterisk indicate data that vary with system operating state or conditions. These items may have different data provided for different modeling scenarios)</th>
<th>dynamics (If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</th>
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<td>3. Governor [GO, RP( for future planned resources only)]</td>
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13 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
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<td>required for aggregate Demand under item 2, above).</td>
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<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
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<td>e. machine MVA base</td>
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<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
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<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
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<td>h. in-service status*</td>
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4. AC Transmission Line or Circuit [TO]
   | a. impedance parameters (positive sequence) |
   | b. susceptance (line charging) |
   | c. ratings (normal and emergency)* |
   | d. in-service status* |

5. DC Transmission systems [TO]

6. Transformer (voltage and phase-shifting) [TO]
   | a. nominal voltages of windings |
   | b. impedance(s) |
   | c. tap ratios (voltage or phase angle)* |
   | d. minimum and maximum tap position limits |
   | e. number of tap positions (for both the ULTC and NLTC) |
   | f. regulated bus (for voltage regulating transformers)* |
   | g. ratings (normal and emergency)* |
   | h. in-service status* |
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
### SECTION: APPENDIX VII

#### Modeling of Generator Parameters

1. **Applicable Facilities** - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

#### Modeling Process for Generator Parameters

- The Generator parameter $P_{\text{max}}$ shall be modeled as a gross seasonal maximum capability based on MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.
- Generating plant station service and auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All station service and auxiliary load representations shall:
  1. Be modeled explicitly on the appropriate bus, corresponding to the voltage to which the auxiliary load is served. Model representations of auxiliary load connected to the generating unit bus (Figure VII-1), auxiliary load modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
  2. Be annotated as non-scalable.

---

15 Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the $P_{\text{gen}}$ of a unit with an amount corresponding to the plant auxiliary load.
c. Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

If generating plant station service and auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use “SS” in the Load ID field (Figure VII-4a). If there are more than one aggregated generating plant station service and auxiliary load, use “Sn” in the Load ID field to delineate the multiple aggregated loads.

If generating plant station service and auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “Fn” in the Load ID field to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “Vn” in the Load ID field to designate variable load quantities that do vary with plant dispatch.

![Diagram of load representations](image)

**Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).**

---

**16 “n” represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.**
Modeling of Wind/Solar Renewable Resources $P_{\text{GEN}}$

- **Light load models**: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility's latest five-year average (or replacement data if unavailable) for the SPP coincident Off-Peak hour corresponding to the season of the Light Load case, not to exceed each facility's firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility's long-term firm transmission service amount.

- **On-Peak models**: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility's latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility's firm service amount.

- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build.

- When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

- Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

- For resources that do not have firm service, $P_{\text{GEN}}$ values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is not available, the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

---

**Data Exemption Process**

MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the “Exemption Form” and send it via e-mail to “Engineering Modeling” containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption.

---

17 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.**  **Effective date of section 2 is July 1, 2016.**  **Effective date of section 4 is July 1, 2016.**
SECTION: APPENDIX VIII - BALANCING AND TRANSACTIONS

Background

A core principal of steady-state power flow modeling\(^\text{18}\) is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area\(^\text{19}\). While typically analogous to a Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\(^\text{20}\) loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

\(^{18}\) The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

\(^{19}\) Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).

\(^{20}\) ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (Pgen) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from
imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Data Owners shall submit all transactions data via the EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:

**Transactions Data Requirements**

Figure 2. Four types of inter-SPP pseudo-ties.
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

Data Owner A

Data Owner B

Physical circuitry tie is irrelevant.

Source

Sink

Inter-area Bilateral transaction description

Data Owner A exports MW to Data Owner B
Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
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<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
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<td>3/1/2020</td>
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<td>MW</td>
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<td>Area 2</td>
<td>2</td>
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<td>1</td>
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<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

Figure 3. Example of Inter-area transfer (transaction).
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Responsible Entity #.
   d. From Responsible Entity Name.
   e. To Area #.
   f. To Responsible Entity #.
   g. To Responsible Entity Name.
   h. Transaction ID.
   i. Transaction Start date.
   j. Transaction Stop date.
   k. Firm or Non-Firm Transaction.
   l. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.
## REVISION HISTORY

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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, data owners, equipment, and data submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator's planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC's Transmission Planners, can be found on the SPP corporate website, [www.spp.org](http://www.spp.org). Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, [www.spp.org](http://www.spp.org). The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1) and the provisions of the

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1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT;
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

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2 Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

3 For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.
Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise,

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5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Equivalencing is a general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.
8 Sixth Revised Volume No.1, Attachment AI, Part II-1.
9 Sixth Revised Volume No.1, Attachment AI, Part II-2.
10 Sixth Revised Volume No.1, Part III-30.
11 Sixth Revised Volume No.1, Part III-31
consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted. Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule ("schedule") jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- Appropriate lead times. Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes. In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP's website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP. The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Responsible Entities

Data owners are responsible for providing the data necessary to model their assets to its Transmission Planner(s) and Planning Coordinator(s) as described in this document. Data owners and their respective data submission responsibilities are noted in the NERC standard MOD-032-1.

1. Generator Owners (GO) and Resource Planners (RP) are responsible for submitting modeling data for their existing and future generating facilities respectively.

2. Load Serving Entities (LSE) are responsible for submitting modeling data for their existing and future load corresponding to the case types developed.

3. Transmission Owners (TO) are responsible for submitting modeling data for their existing and future transmission facilities.

4. The Planning Coordinator or Transmission Planner can request other information necessary for modeling purposes from the BA, GO, LSE, TO, or TSP.
Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Spring Peak</td>
<td>Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>Annual Summer Shoulder</td>
<td>Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>Annual Summer Peak</td>
<td>Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>Annual Fall Peak</td>
<td>Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>Annual WinterPeak</td>
<td>Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 April Minimum</td>
<td>Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>Annual + 1 Spring Peak</td>
<td>Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 Summer Shoulder</td>
<td>Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission to data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

Data Transmittal

Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic --- GlobalScape**
2. **E-MAIL --- SPPEngineeringModeling@spp.org**

The preferred method of submittal is through the "SPP MDWG File Sharing Site", GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP,*04FA,*04SH,*07SP [no spaces between characters].
SPP Model Release Guidelines

Steady-State and Short Circuit Models

SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If equivalized, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.

SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables

Regional Coordinators

The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format; regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   Initialized steady state and regional contingency cases.
a. Steady-State RAWD case file
b. Conversion IDEV files
2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case
4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

SPP Members
The SPP Members are identified on the SPP Website. See the “Members” link under “About SPP” on www.SPP.org.

MDWG Contact List
The MDWG Contact List can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

ACRONYMS

ATC – Available Transfer Capability
CAP – Capacitor
EIA – Energy Information Act
ERAG – Eastern Interconnection Reliability Assessment Group
ERCOT – Electric Reliability Council of Texas
FPC – Federal Power Commission
IDEV – Input Device (PSS®E Dialog Input Device Selection Activity)
LTC – Load Tap Changing
MAPP – Mid-Continent Area Power Pool
MAIN – Mid-American Interpool Network
MBASE – Machine Base
MDWG – Model Development Working Group
MMWG – Multiregional Modeling Working Group
MW – Megawatt
MW – Megawatt
NERC – North American Electric Reliability Corporation
PSS®E – Power System Simulator for Engineers
PTI – Power Technologies, Inc.
pu – Per-unit
RAWD – Raw Data
RDCH – Read Change (Command to read in and change data in PSS®E)
**SPP Model Development Procedure Manual**

**REAC** – Reactor  
**SERC** – Southeastern Electric Reliability Council  
**SPP** – Southwest Power Pool, Inc.  
**STEP** – SPP Transmission Expansion Plan  
**TWG** – Transmission Working Group  
**WSCC** – Western Systems Coordinating Council  
**ZSOURCE** – Zero Impedance

**NOTE** – A complete listing of other SPP acronyms can be found on the SPP website at [www.spp.org](http://www.spp.org) SPP Glossary. See the “Glossary and Acronyms” link under “Training”.

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**Compliance**

1. MDWG Model Development Procedure Manual  
   Note: The latest document can be found on SPP.org  

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list  
   Note: The latest document can be found on SPP.org  

3. Data Submittal Forms (This is a separate document)  
   Note: The latest document is posted with every model set  

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

1. The Steady-State data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

ENGINEERING DATA SUBMISSION TOOL

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
</tbody>
</table>

Table 1: Season Date Range and Cutoff Dates
Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be Non-Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand. DSM consists of controllable and non-controllable systems. Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. Distributed Energy Resources are power resources on the distribution system that can be aggregated together to provide power to meet Demand. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed agreement, or are in the process of finalizing a signed agreement should be included in the Data Submitter’s load forecast. SPP may reject any MOD projects or PSS® IDEV ideas that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or
any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Non-coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

On-Peak/Off-Peak Models
Seasonal On-Peak models developed by SPP include: Summer Peak, Winter Peak, Spring Peak, and Fall Peak. These four seasonal On-Peak models are built to represent the anticipated coincident seasonal peaks based on each individual Data Owner/Data Submitter’s respective seasonal On-Peak load. Data Owner/Data Submitter’s On-Peak load may not be coincident with the instance of the SPP Balancing Authority coincident On-Peak.

The Summer Shoulder On-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder On-Peak loading is representative of the average of the anticipated summer season daily peak hours.

In addition to the seasonal On-Peak models, SPP develops one two Off-Peak model which is a Spring Light Load condition and a Summer Shoulder condition.

The Spring Light Load Off-Peak model is developed with the intent to capture each individual Data Owner/Data Submitter’s system minimum load during the spring timeframe.

<table>
<thead>
<tr>
<th>Model</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Peak (S):</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall Peak (F):</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter Peak (W):</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Light Load (L):</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Shoulder (SH):</td>
<td>70% - 80% of Summer Peak model</td>
</tr>
</tbody>
</table>

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.

Load Data
Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.
The Non-Scalable Loads will be identified in the Non-Scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID “R1”). These loads should be maintained in the Load Mapping worksheet of the EDST.

Area Summary Report
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.
12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.
Tie Line Coordination
Each SPP system will receive a tie-line data comparison summary for the initial base case and after
the final models are published. The member must coordinate with its neighbors on the tie line
representation in the models being developed.
This coordination should consist of:
1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the
tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities
must submit changes using the latest list, which will be posted with the latest case set. Changes
are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file
name shall contain the company name of which is submitting the change. There will be other
lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP
tie line reports.

Line and Transformer Data
Additions to the system tend to move from year-to-year based on changing load growth forecasts
and budget requirements. As a result, future lines and transformers may move through several
future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type,
Status, and Phase Effective Date determine if the data will be included in a particular model. The
line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to
   the base case. The action code (Add, Modify, Delete) specifies the action to be taken
   with the Project data. Specifying the deletion of a bus will require a similar record to
   delete all associated or connected devices with the bus (lines, generators, loads,
   transformers, etc.) from the base case.

2. The "from bus," “to bus”, and circuit number identify the line or transformer. The
   order in which bus numbers are entered is important for tie lines to identify which
   bus is metered for loss accounting in some data formats. The "from bus" is assumed
   to be the metered end (unless the "to bus" is entered with a negative) and the “to
   bus” area will collect loss responsibility. For transformers, this order is also
   important in all formats because it specifies to which bus the Load Tap Changer
   (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in
   the branch data allows the user to select proper metered and tapped side by always
   entering the tapped side as the "from bus" or first bus number after the change code.
   The “from bus” is the metered end unless the “to bus” or second bus number is a
   negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance data shall be provided
   on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011
   P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-
   state program to treat the line as a zero impedance line to reduce solution time.
4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be divided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each SPP member shall rate transmission circuits in accordance with the SPP Planning Criteria (Section 7.2). This criterion calls for each member to compute, at a minimum, summer and winter seasonal ratings for each circuit element. Each Base Case (Network) and Project branch, two-winding and three-winding transformer must have a specified rate A (normal) and rate B (long-term emergency) for spring, summer, fall, and winter. The ratings data format is in the MOD Procedure Manual.

6. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

7. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

8. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

9. Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

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12 Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

**NOTE:** When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Below 69 kV</td>
<td>1</td>
</tr>
<tr>
<td>2 - 69 kV</td>
<td>2</td>
</tr>
<tr>
<td>3 - 115 kV</td>
<td>3</td>
</tr>
<tr>
<td>4 - 138 kV</td>
<td>4</td>
</tr>
<tr>
<td>5 - 161 kV</td>
<td>5</td>
</tr>
<tr>
<td>6 - 230 kV</td>
<td>6</td>
</tr>
<tr>
<td>7 - 345 kV</td>
<td>7</td>
</tr>
<tr>
<td>8 - 500 kV</td>
<td>8</td>
</tr>
<tr>
<td>9 - 765 kV or above</td>
<td>9</td>
</tr>
</tbody>
</table>

1. For generator regulated buses, a desired voltage magnitude will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.
2. Bus loads should be specified with the real and reactive values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent "hunting" of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.

**Generator Data**

Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and Mbase limits per testing requirements in SPP Planning Criteria 7.1.1. Generator MW shall be set to "gross" level with auxiliary load modeled explicitly. Qmax and Qmin values in the models should be based on unit test data. Intermittent resources (e.g., wind and run-of-river hydro) should not normally be dispatched beyond their net capability as established by SPP Planning Criteria 7.1 for the summer and shoulder cases. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the sub unsaturated transient impedance for those generators modeled by sub transient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine Base (MBASE) and Zero Impedance (ZSOURCE) values for the steady-state models must match dynamic data. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X''di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.

**Modeling of Generator Parameters**

1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)
Modeling Process for Generator Parameters

a. The Generator parameter $P_{\text{MAX}}$ shall be modeled as a gross seasonal maximum capability based on MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

b. Generating plant station service and auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All station service and auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus 13, corresponding to the voltage to which the auxiliary load is served. Model representations of auxiliary load connected to the generating unit bus (Figure VII-1), auxiliary load modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

c. Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

   If generating plant station service and auxiliary load is aggregated, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use “SS” in the Load ID field (Figure VII-4a). If there are more than one aggregated generating plant station service and auxiliary load, use “Sn” in the Load ID field to delineate the multiple aggregated loads.

   If generating plant station service and auxiliary load is not aggregated, each load

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13 Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant auxiliary load.
quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “Fn” in the Load ID field\(^\text{14}\) to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “Vn” in the Load ID field\(^\text{14}\) to designate variable load quantities that do vary with plant dispatch.

Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).

d. The Generator Parameters for PMIN, AUX Load, QMAX, and QMIN shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

Modeling of Wind/Solar Renewable Resources P\(_{\text{GEN}}\)

- Light load models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP coincident Off-Peak hour corresponding to the season of the Light Load case, not to exceed each facility’s firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

- On-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident\(^\text{15}\) peak, not to exceed each facility’s firm service amount.

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\(^{14}\) "n" represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.

\(^{15}\) SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
• SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build.

• When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

• Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

• For resources that do not have firm service, $P_{GEN}$ values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

Data Exemption Process
MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the "Exemption Form" and send it via e-mail to "Engineering Modeling" containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.**
**Effective date of section 2 is July 1, 2016.**
**Effective date of section 4 is July 1, 2016.**

Shortfall Guidance Process
A shortfall is defined as an instance of insufficient firm resource to supply firm load. Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   e. The in-service date shall be based on the expected in-service date of the GI study.
Remote Generation Modeling

Purpose
This procedure assures that members adhere to a uniform process when modeling remote generation in SPP.

Modeling Process
If a member acquires remote generation outside their Control Area (steady-state model numbered area), the following modeling process should be followed:

1. All buses should be assigned numbers that are in the host's control area bus number range.
2. Area Number/Name should be the host's control area number.
3. Zone Number/Name should be in the host's control area zone range.
4. Generation Owner Number should be the owner's designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Owner Data and Line Mileage Data (SAS-70 Control)

Per SAS-70 SSAE requirements (i.e., Loss calculations) SPP Loss Reactive Matrix (MW-Mile) models must be updated every June and October with current Owner Data and Line Mileage data. To meet the SAS-70 SSAE requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:

1. Zone Range Assignments
2. System Codes
3. Utilized DC Lines
Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
   Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
   The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking
of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

a. **Voltage Summaries**
   Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

   Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

   The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

   Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**
   This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**
   All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

   The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation
must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. QT --- MAX = one-half of MW rating

ii. QB --- MIN = negative one-third of MW rating

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

POI – Point Of Interconnection
MPT – Main Power Transformer
GSU – Generator Step-Up Transformer
N – Number of turbines/inverters/GSU transformers
# – Number of Modules/String

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)

POI – Point Of Interconnection
MPT – Main Power Transformer
GSU – Generator Step-Up Transformer
N – Number of turbines/inverters/GSU transformers
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc…) There are several ways of submitting changes to the steady-state models.

Two of these methods are:

1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI IDEV format file to perform the RDCH operation. **This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.**

   It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.
Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format

Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in “free format” with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data for that bus will be removed (e.g., branches, transformers, generators, and loads). The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified. Data currently in the model is used as the default value for data fields not specified in the format.

Steady-State Solution

The steady-state solution will have “Area interchange control” with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

Error Screening

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the
problem is corrected.

Steady-State Modeling Requirements

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.

2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the Xsource value in the steady-state generator data record shall be as follows:
   a. Xsource = X''d for detailed synchronous machine modeling
   b. Xsource = X'd for non-detailed synchronous machine modeling
   c. Xsource = should be equal to locked rotor impedance for an induction machine
   d. Xsource = 1.0 per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E dynamic library models compatible with either representation are available. If a user model representing particular SVC and control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.
If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using $R=0.00000 + X=0.00001$ and $B=0.00000$. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of $R=0.0001 + X=0.002$ and $B=0.00000$. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalented, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – Effective with Revision 28 of PSS®E, off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding. The measured impedance (resistive and inductive) between each pair of windings shall be specified: data entry options permit these to be entered in (1) per unit on system (100 MVA) base; (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage.

9. Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

10. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

11. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes. PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is
entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:

a. Real-time operational auto or manual adjustment operation of the PST.
b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
c. Real-time operational MW flow limits (e.g. ±20 MW).
d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
f. Applicable long-term firm transmission service levels for the PST.

12. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

13. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

14. Out-of-Service Generator Modeling – Out-of-service generators should be modeled with a STATUS equal to zero.

15. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

17. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively
regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

18. Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

19. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

20. Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

21. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

22. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

23. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point and equipment status, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation.

24. HVDC – All HVDC transmission facilities must be represented with a sufficiently detailed model to simulate its expected behavior.

25. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

26. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

Causes of Non-convergence and Problems in Merged Base Case Models
Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it. (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during equivalencing.

4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. Fictitious regulation of buses.

12. Extremely low voltage schedules.

13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area. While typically analogous to a Balancing Authority Area or control area, the concept of a model area is straightforward: model areas

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16 The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

17 Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\textsuperscript{18} loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

![Figure 1. Example of interconnected model areas.](image)

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (P\textsubscript{gen}) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the

\textsuperscript{18} ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
   a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole

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**Figure 2. Four types of inter-SPP pseudo-ties.**
MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

Inter-area Bilateral transaction description

Data Owner A exports MW to Data Owner B
Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>From</th>
<th>Data Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>1</td>
<td>Data Owner A</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

Figure 3. Example of Inter-area transfer (transaction).
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where remote generation is located to the generation owner control area. If the remote generation is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area's number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

**No Transaction Needed**
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

**Transaction Needed**
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long
Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).
System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

Entities in the SPP Planning Coordinator region that are not members of the SPP but required to submit data (i.e. IPPs, Municipalities) will submit data directly to the Transmission Owner or Balancing Authority in which their system resides. Upon review (i.e. data accuracy, quality) by the Transmission Owner or Balancing Authority the data will then be provided to the SPP during the annual MDWG case type update process. The data submitted will be in the standard PTI format as specified in the MDWG Model Development procedure manual. All non-SPP members that are responsible for submitting this data should directly coordinate with the Transmission Owner or Balancing Authority on timing for sending data, as well as any special requirements in data formatting.

In an effort to determine who is collecting/submitting data for whom, all NERC registered entities within the SPP PC footprint (MOD-032-1: applicable to BA, GO, LSE, RP, TO, TP, and TSP) shall fill out the data coordination workbook to notify SPP if data is being submitted directly to SPP or through some other entity(ies) on behalf of your company. Likewise, SPP shall be notified if your company is submitting data on behalf of another entity(ies).

Schedule

As with all schedules, the meeting of deadlines is most critical. All system representatives must familiarize themselves with the schedule well in advance of all deadlines. This will alleviate any problems with the timing of data submittal and data reviews. The schedule for model development will be sent with the first data request as well as posted on the SPP corporate website, www.spp.org.

Steady-State and Short-Circuit Model Development

The MDWG Steady State and Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.
Steady-State Data Check List

The steady-state data check list should be used as an aid for ensuring good model data. As the data and preliminary runs are reviewed for each model, the items should be checked off. A copy of this form can be found in Section 7.

Facilities Transferred to SPP’s Functional Control

The SPP FERC “Docket No. RT04-01-00 Volume 1”, In the July 2 Order, the Commission…(7) ordered that SPP file a list of all transmission facilities that will be transferred to its operational control and revise the Operational Authority White Paper (“OA White Paper”) or Membership Agreement, or provide some other binding document, to reflect SPP’s clear authority to exercise day-to-day control over the appropriate transmission facilities within its footprint…

Attachment AI to the SPP Regional Tariff contains the criteria for inclusion of facilities that are considered “Facilities Transferred to SPP’s Functional Control”. Transmission facilities meeting the definition set forth in Attachment AI must be included in the SPP MDWG Steady-State Models.

SPP Area
Refer to the most current SPP Area Zone Assignments.

<table>
<thead>
<tr>
<th>Region</th>
<th>Bus Numbers</th>
<th>Area Number</th>
<th>Zone Number</th>
<th>Owner Numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entire System</td>
<td>100,000 to 899,999</td>
<td>100 to 899</td>
<td>100 to 1,899</td>
<td>100 to 1,199</td>
</tr>
<tr>
<td>NERC</td>
<td>100,000 to 199,999</td>
<td>100 to 199</td>
<td>100 to 1,199</td>
<td>100 to 199</td>
</tr>
<tr>
<td>RFC</td>
<td>200,000 to 299,999</td>
<td>200 to 299</td>
<td>200 to 1,299 and 1,800 to 1,899</td>
<td>200 to 299</td>
</tr>
<tr>
<td>SERC</td>
<td>300,000 to 399,999</td>
<td>300 to 399</td>
<td>300 to 1,399</td>
<td>300 to 399</td>
</tr>
<tr>
<td>ERC</td>
<td>400,000 to 499,999</td>
<td>400 to 499</td>
<td>400 to 1,499</td>
<td>400 to 499</td>
</tr>
<tr>
<td>SPP</td>
<td>500,000 to 599,999</td>
<td>500 to 599</td>
<td>500 to 1,599 and 800 to 899</td>
<td>500 to 599 and 800 to 899</td>
</tr>
<tr>
<td>MRO</td>
<td>600,000 to 699,999</td>
<td>600 to 699</td>
<td>600 to 1,699</td>
<td>600 to 699</td>
</tr>
<tr>
<td>ERCOT (future)</td>
<td>700,000 to 799,999</td>
<td>700 to 799</td>
<td>700 to 1,799</td>
<td>700 to 799</td>
</tr>
</tbody>
</table>

AC Contingency Analysis

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

Dynamic Model Development

Introduction
The MDWG Dynamic Models include full MMWG cases and machine reduced cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model Update is used to support SPP reliability studies and ERAG MMWG Dynamic model requirements. It is important for all generating entities that interconnect to the SPP transmission to support the Regional Transmission Organization with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic Model Format is PSS®E dynamics DYRE and RAWD formats.

The Dynamics Model data includes:
1. Steady-State models
2. Dynamics model data in Siemens PTI PSS®E DYRE format
3. User written model source and object code (includes wind farms)
4. ERAG MMWG System Dynamics Database (SDDB)
5. SDDB data update worksheet

SPP MDWG Dynamic Models are published according to the schedule in Section 15 B.

The Dynamic data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Dynamics Model is also updated annually with current generator unit information. Steady-State models are used in conjunction with dynamic data to run dynamic simulation.

Procedures for Initialization and No-Disturbance Checks Of Library DYNAMICS Cases

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
iii. Source impedances equal to or less than zero. These will cause
generator conversion to fail.
iv. Real and/or reactive power limits of +9999 or -9999.
c. Checks which report abnormal values
v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
vi. Bus voltages below 0.95 p.u. except in the case of generator
terminal voltage buses connected to the transmission bus by a
step-up transformer with a tap ratio significantly off nominal.
[vchk]
vii. Overloaded generators. [geol]. Note that this activity checks
machine output against the machine MVA base, Mbase, not
against PMAX, PMIN, QMAX, and QMIN.
viii. Branches with extreme impedances or tap ratios [brch].
Suggested options are:
a) Small impedance. Note that very small impedances can be treated as zero
impedance ties by selection of parameter THRESHZ and these will not be a
problem.
b) Negative reactance. These are typically found in Y representations of three
winding transformers. Solution activity SOLV may not be used on cases
containing such branches and MSLV may not be used if they are present at
a Type 2 or 3 (generator) bus.
c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are
normal on long EHV lines but others should be checked. Negative values
are occasionally used for magnetizing impedance on transformers but this
usage is not recognized in the PSS®E Program Operation Manual.
d) Parallel transformers. Minor tap ratio differences may simply reflect field
conditions, but differences exceeding one step should be checked to guard
against inadvertent errors.
e) High tap ratios.
f) Low tap ratios.
d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage
return” for no change.
i. Generators dispatched outside their real power limits [scal]. Scaling areas or
zones should be used cautiously if generators having default PMAX (+9999)
and PMIN (-9999) limits are present.
ii. Inconsistent targets at a bus whose voltage is controlled by two or
more system elements: local generation, switched shunts, and
voltage controlling transformers. [cntb]. There is a tendency not
to recognize different summer and winter operating strategies
where appropriate.
iii. Questionable voltage or flow controlling transformer parameters.
[tpgh]
iv. Buses in “islands” not containing a system swing bus. [tree].
Note that there can be multiple islands each of which does contain
a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas
comprising one region, proceed as follows.
a. Create a raw data file containing only the area(s) of interest. [rawd, area]
b. Read in the raw data file just created. [read]
c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]
d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].
e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE].

5. From the dynamics entry point, read in the dynamic model data file [DYRE]. (Load flow case must also be in memory.)
   a. Specify CONEC, CONET, and COMPILE files.
   b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using "user dynamics".
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE].
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN].
      Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.

      ii. A tabulation of conditions at each online machine
         a) Terminal voltage
         b) Exciter output voltage
         c) Real and reactive power output
         d) Power factor
         e) Machine angle in degrees
         f) Direct and quadrature axis currents on machine base.
      iii. A diagnosis of initial conditions, either
         a) "Initial conditions check OK", or
         b) A listing of suspect initial conditions generally states whose time derivative is not "small" (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.

      iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems.
This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of:
   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 "non-continuous" regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((- \frac{1}{K})\) = \((- \frac{1}{R})\), mechanical power to \((1-\frac{1}{K})\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Dynamic Data Format

**PSS®E Users**

Dynamic data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

**Non-PSS®E Users**

Dynamic data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

NERC maintains a list of acceptable dynamic models on the NERC website for reference by the GO. Only
NERC acceptable dynamic models from the latest approved list shall be provided to the applicable TPs and to SPP, as PC, for dynamic model building purposes. The acceptable dynamic model list can be found on the NERC SAMS website → SAMS Reference Materials → NERC Acceptable Model List.

Dynamic models that are considered unacceptable by NERC, shall be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:
1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis.
2. Dynamic model data is submitted in .dyr format.
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes.
4. Documentation, including Block Diagram, in .pdf or .docx format.
5. A written commitment to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

**Dynamics Data Submittal Requirements and Guidelines**

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The PSS®E dynamic model types classified as detailed are GENROU, GENSAL, GENROE, GENSAE, and GENDCO.

   The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because the manufacturer no longer in business.
   b. Detailed data is not available because the unit is older than 1970.

   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.

   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
   c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

Dynamics Data Validation Requirements

1. All dynamics modeling data shall be screened according to the SDDB data screening checks.

2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines
1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc).
2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator
Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template
Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready. The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>of a dynamics model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add a new model to an existing</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another</td>
<td>Bus name, unit ID, model name for deleted model</td>
<td>Yes for new model</td>
<td>1. A DC exciter is replaced by a static exciter. 2. A classical machine model</td>
</tr>
<tr>
<td>model of the same equipment</td>
<td></td>
<td></td>
<td>is replaced by a detailed model.</td>
</tr>
<tr>
<td>group</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change bus name and/or unit</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>ID for all</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>models of an existing unit</td>
<td></td>
<td></td>
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<tr>
<td>--------------------------</td>
<td>------------------------</td>
<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>Change bus number</td>
<td>No</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
<td>Same requirements whether unit is at new or existing bus.</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Complete Set of Dynamics Data**
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDBB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDBB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDBB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

1. The Short Circuit data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data. The sequence data is comprised of positive, zero, and negative sequence data. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final). The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the Reliability Steady-State models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case
The Base MDWG Short Circuit models are built by performing the following steps:
1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company's RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:
1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:
1. Place in-service (Apply a status of '1') all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions
**FORMS — Area Summary Report**

<table>
<thead>
<tr>
<th>CASE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Generation</td>
<td></td>
</tr>
<tr>
<td>Purchases (-)/Sales (+)</td>
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<tr>
<td>To/From Area Name</td>
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</table>

<table>
<thead>
<tr>
<th>CASE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Total Interchange</td>
<td></td>
</tr>
<tr>
<td>3. Net Power (1-2)</td>
<td></td>
</tr>
<tr>
<td>4. Load</td>
<td></td>
</tr>
<tr>
<td>5. Losses</td>
<td></td>
</tr>
<tr>
<td>6. Net Load (4+5)</td>
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</tr>
<tr>
<td>7. Slack Bus Generation</td>
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</tr>
<tr>
<td>8. Slack Bus Number &amp; Name</td>
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</tr>
</tbody>
</table>

**Note:**

<table>
<thead>
<tr>
<th>Area Name &amp; Number:</th>
<th>Prepared By:</th>
<th>Telephone Number:</th>
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### FORMS—Steady-State Data Checklist

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<th>PREPARED BY:</th>
<th>TELEPHONE NUMBER:</th>
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<tr>
<td>BUS DATA</td>
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<tr>
<td>Names - 12 characters</td>
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<tr>
<td>Voltage Codes</td>
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<tr>
<td>Power Factor</td>
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<tr>
<td>Load - Real</td>
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<tr>
<td>Reactive Load</td>
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</tr>
<tr>
<td>Voltage</td>
<td></td>
<td></td>
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<tr>
<td>Fixed Shunts - Reactors</td>
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<tr>
<td>Capacitors</td>
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<tr>
<td>Dynamic Shunts - SVC’s</td>
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</tr>
<tr>
<td>Synchronous Condensors</td>
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<tr>
<td>Generation - Dispatch/Net</td>
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<tr>
<td>Reactive Output</td>
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<tr>
<td>Reactive Limits</td>
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<td>Regulated Voltages</td>
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<tr>
<td>Generator Rating</td>
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<tr>
<td>Slack Bus</td>
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<td>LINE DATA</td>
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<td>Ratings - Normal</td>
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<td>Emergency</td>
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<tr>
<td>Impedance - Resistance</td>
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<tr>
<td>Reactance</td>
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<td>Charging</td>
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<tr>
<td>Flows</td>
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<tr>
<td>Transformers - Taps</td>
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<td></td>
</tr>
<tr>
<td>Tap Ranges</td>
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<tr>
<td>Regulated Bus</td>
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<td>OTHER DATA</td>
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<td>Area Transactions</td>
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</tbody>
</table>

**Note:**
SECTION 6: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,
From Area Name,
From Bus#, 
From Bus Name,
From Bus kV,
To Region Name,
To Area#,
To Area Name,
To Bus#,
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI (pu),
BI (pu),
GJ (pu),
BJ (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area #,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area #,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM11,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#, 
Winding 1 Area Name, 
Winding 1 Bus#, 
Winding 1 Bus Name, 
Winding 1 Bus kV, 
Winding 2 Region Name, 
Winding 2 Area#, 
Winding 2 Bus Name, 
Winding 2 Bus#, 
Winding 2 Bus kV, 
Winding 3 Region Name,
Winding 3 Area#, 
Winding 3 Area Name, 
Winding 3 Bus#, 
Winding 3 Bus Name, 
Winding 3 Bus kV, 
CKT, 
CW, 
CZ, 
CM, 
MAG1, 
MAG2, 
NMETR(1,2,3), 
NAME, 
STATUS(0,1), 
Owner 1, 
Fraction 1, 
Owner 2, 
Fraction 2, 
Owner 3, 
Fraction 3, 
Owner 4, 
Fraction 4, 
R1-2, 
X1-2, 
SBase1-2, 
R2-3, 
X2-3, 
SBASE2-3, 
R3-1,
Three Winding Transformer Data Fields - continued
X3-1, SBASE3-1, VMSTAR, ANSTAR, WindV1, NomV1, Ang1, Summer Rating A1, Summer Rating B1, Summer Rating C1, Winter Rating A1, Winter Rating B1, Winter Rating C1, COD1, Control Bus 1 Region, Control Bus 1 Area Number, Control Bus 1 Area Name, Control Bus #(CONT1), Control Bus Name, Control Bus KV, RMA1, RMI1, VMA1, VM1, NTP1, TAB1, CR1, CX1, WindV2, NomV2, Ang2, Summer Rating A2, Summer Rating B2, Summer Rating C2, Winter Rating A2, Winter Rating B2, Winter Rating C2, COD2, Control Bus 2 Region, Control Bus 2 Area Number, Control Bus 2 Area Name, CONT2, Control Bus 2 Name, Control Bus 2 KV, RMA2,
Three Winding Transformer Data Fields - continued

Two Terminal DC Tie Data Fields

In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (R,I),
DCVMIN,
CCCITMX,
CCCACC,
IPR REGION NAME,
IPR AREA#, 
IPR AREA NAME,
IPR Bus#,
IPR BUS NAME,
IPR BUS kV,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#, 
ICR AREA NAME,
ICR BUS#,
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#, 
IFR AREA NAME,
IFR BUS#,
IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields
ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME, 
ITR BUS KV, 
IDR, 
XCAPR, 
IPI REGION NAME, 
IPI AREA#, 
IPI AREA NAME, 
IPI BUS#, 
IPI BUS NAME, 
IPI BUS KV, 
NBI, 
GAMMX, 
GAMMN, 
RCI, 
XCI, 
EBASI, 
TRI, 
TAPI, 
TMXI, 
TMNI, 
STPI, 
ICI REGION NAME, 
ICI AREA#, 
ICI AREA NAME, 
ICI BUS#, 
ICI BUS NAME, 
ICI BUS KV, 
IFI REGION NAME, 
IFI AREA#, 
IFI AREA NAME, 
IFI BUS#, 
IFI BUS NAME, 
IFI BUS KV, 
ITI REGION NAME, 
ITI AREA#, 
ITI AREA NAME, 
ITI BUS#, 
ITI BUS NAME, 
ITI BUS KV, 
IDI, 
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements. 
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
### SECTION: APPENDIX II

**NUMBER RANGE ASSIGNMENTS FOR ERAG MMWG STEADY-STATE DATA**

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<tr>
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<th>Bus Numbers</th>
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<th>Zone Numbers</th>
<th>Owner Numbers</th>
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<td>100 to 1,899</td>
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<tr>
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<td>100,000 to 199,999</td>
<td>100 to 199</td>
<td>100 to 199 and 1,100 to 1,199</td>
<td>100 to 199</td>
</tr>
<tr>
<td>RFC</td>
<td>200,000 to 299,999</td>
<td>200 to 299</td>
<td>200 to 299 and 1,200 to 1,299 and 1,800 to 1,899</td>
<td>200 to 299</td>
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<tr>
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<td>500 to 599 and 1,500 to 1,599</td>
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<td>700 to 799 and 1,700 to 1,799</td>
<td>700 to 799</td>
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1. Area or zone number 1 is sometimes used as a default when the number is omitted by mistake. Its use to number an actual area should be avoided.

Commented [MO4]: Referenced above, should be in steady state
## SECTION 7: APPENDIX III
### UTILIZED IMPEDANCE CORRECTION TABLES

| Table Number | Tap or Angle | 1 Factor | 2 Factor | 3 Factor | 4 Factor | 5 Factor | 6 Factor | 7 Factor | 8 Factor | 9 Factor | 10 Factor | 11 Factor | 12 Factor | 13 Factor | 14 Factor | 15 Factor | 16 Factor | 17 Factor | 18 Factor | 19 Factor | 20 Factor | 21 Factor | 22 Factor | 23 Factor | 24 Factor | 25 Factor | 26 Factor | 27 Factor | 28 Factor | 29 Factor | 30 Factor | 31 Factor | 32 Factor | 33 Factor | 34 Factor | 35 Factor | 36 Factor | 37 Factor | 38 Factor | 39 Factor | 40 Factor | 41 Factor | 42 Factor | 43 Factor | 44 Factor |
|--------------|--------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
## SECTION: APPENDIX IV

### UTILIZED DC LINES

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### SECTION: APPENDIX V
### SYSTEM CODES FOR USE IN ERAG MMWG STEADY-STATE DATA

#### NPCC – Northeast Power Coordination Council

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<td>TE</td>
<td>TransEnergie</td>
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<tr>
<td>105</td>
<td>NB</td>
<td>New Brunswick Power</td>
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<tr>
<td>106</td>
<td>NS</td>
<td>Nova Scotia Power</td>
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<td>CORNWALL</td>
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#### RFC – Reliability First Corporation

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<td>American Electric Power</td>
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<td>OVEC</td>
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<td>DEM</td>
<td>Duke Energy Midwest</td>
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<td>DAY</td>
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<td>TECO</td>
<td>Tampa Electric Company</td>
</tr>
<tr>
<td>417</td>
<td>FMP</td>
<td>FMPA / City of Vero Beach</td>
</tr>
<tr>
<td>418</td>
<td>NUG</td>
<td>Non-Utility Generators</td>
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<tr>
<td>419</td>
<td>RCU</td>
<td>Reedy Creek Energy Services, INC.</td>
</tr>
<tr>
<td>421</td>
<td>TCEC</td>
<td>Treasure Coast Energy Center</td>
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<tr>
<td>426</td>
<td>OSC</td>
<td>Osceola at Halsepaw (PEF)</td>
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<tr>
<td>427</td>
<td>OLEANDER</td>
<td>Oleander IPP at Brevard (FPL)</td>
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<td>428</td>
<td>CALPINE</td>
<td>Calpine at Recker (TECO)</td>
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<td>431</td>
<td>VAN</td>
<td>IPS Avon Park at Vandolah (PEF)</td>
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<td>433</td>
<td>IPS</td>
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<td>DESOTOGEN</td>
<td>Desoto Generation IPP at Whidden (FPL)</td>
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<tr>
<td>438</td>
<td>IPP-REL</td>
<td>Reliant at Indian River (FMPP)</td>
</tr>
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</tr>
<tr>
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<tr>
<td>502</td>
<td>CELE</td>
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<tr>
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<tr>
<td>504</td>
<td>LEPA</td>
<td>Louisiana Energy and Power Authority</td>
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<td>505</td>
<td>ALEX</td>
<td>City of Alexandria</td>
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<tr>
<td>507</td>
<td>RAYB</td>
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<tr>
<td>508</td>
<td>NTEC</td>
<td>North Texas Electric Cooperative</td>
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<td>509</td>
<td>SNCT</td>
<td>Sam Rayburn G&amp;T</td>
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<td>511</td>
<td>AREE</td>
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<td>CLWL</td>
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<tr>
<td>514</td>
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<tr>
<td>515</td>
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<td>Southwestern Power Administration</td>
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<tr>
<td>520</td>
<td>AEPW</td>
<td>American Electric Power</td>
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<td>522</td>
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<td>526</td>
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<td>531</td>
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<td>543</td>
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<td>545</td>
<td>INDN</td>
<td>City of Independence</td>
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<td>546</td>
<td>SPRM</td>
<td>City Utilities of Springfield</td>
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<tr>
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<td>MRO</td>
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<tr>
<td>600</td>
<td>XEL</td>
<td>Xcel Energy North</td>
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<tr>
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<td>MUNI</td>
<td>Municipal data from Xcel Energy</td>
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<td>MMPA</td>
<td>MMPA Municipal data from Xcel Energy</td>
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<td>627</td>
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<td>Alliant Energy West</td>
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<td>633</td>
<td>MPW</td>
<td>Muscatine Power &amp; Water</td>
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<td>IAMU</td>
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<td>645</td>
<td>OPPD</td>
<td>Omaha Public Power District</td>
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<td>652</td>
<td>WAPA</td>
<td>Western Area Power Administration</td>
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<tr>
<td></td>
<td>MPC</td>
<td>Minnkota Power Cooperative, Inc.</td>
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<tr>
<td></td>
<td>BEPC</td>
<td>Basin Electric Power Cooperative</td>
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<td></td>
<td>NWPS</td>
<td>Northwestern Public Service</td>
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<td>MRES</td>
<td>Missouri River Energy Services</td>
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<tr>
<td>661</td>
<td>MDU</td>
<td>Montana-Dakota Utilities Co.</td>
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<tr>
<td>667</td>
<td>MHEB</td>
<td>Manitoba Hydro</td>
</tr>
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<td>SPC</td>
<td>Saskatchewan Power Co.</td>
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<td>680</td>
<td>DPC</td>
<td>Dairyland Power Cooperative</td>
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<td>694</td>
<td>AL TE</td>
<td>Alliant Energy-East (ATC)</td>
</tr>
<tr>
<td>696</td>
<td>WPS</td>
<td>Wisconsin Public Service Corporation (ATC)</td>
</tr>
<tr>
<td></td>
<td>CWP</td>
<td>Consolidated Water Power Company (ATC)</td>
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<tr>
<td></td>
<td>MEWD</td>
<td>Marshfield Electric and Water Company (ATC)</td>
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<tr>
<td></td>
<td>MPU</td>
<td>Manitowoc Public Utilities (ATC)</td>
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<tr>
<td>697</td>
<td>MGE</td>
<td>Madison Gas and Electric Company (ATC)</td>
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<tr>
<td>698</td>
<td>UPPC</td>
<td>Upper Peninsula Power Company (ATC)</td>
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<table>
<thead>
<tr>
<th>Area #</th>
<th>ID</th>
<th>System</th>
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</thead>
<tbody>
<tr>
<td>700</td>
<td>ERCOT</td>
<td>ERCOT Electric Reliability Council of Texas, Inc.</td>
</tr>
<tr>
<td>800</td>
<td>WECC</td>
<td>Western Electricity Coordinating Council</td>
</tr>
</tbody>
</table>
The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Items marked with an asterisk indicate data that vary with system operating state or conditions. These items may have different data provided for different modeling scenarios)</td>
<td>(If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</td>
<td></td>
</tr>
<tr>
<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>a. Positive Sequence Data</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>b. Negative Sequence Data</td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td>5. Demand [LSE]</td>
<td>2. Mutual Line Impedance Data [TO]</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td>6. Wind Turbine Data [GO]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>3. Generating Units20 [GO, RP (for future planned resources only)]</td>
<td>7. Photovoltaic systems [GO]</td>
<td></td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
<td></td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td>9. DC system models [TO]</td>
<td></td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide data in the same</td>
<td>10. Other information requested by the Planning Coordinator or Transmission Planner</td>
<td></td>
</tr>
</tbody>
</table>

19 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
manner as that
required for aggregate
Demand under item 2,
above).
d. regulated bus* and
voltage set point* (as
typically provided by
the TOP)
e. machine MVA base
f. generator step up
transformer data
(provide same data as
that required for
transformer under item
6, below)
g. generator type (hydro,
wind, fossil, solar,
uclear, etc)
h. in-service status*  
4. AC Transmission Line or
Circuit [TO]
a. impedance parameters
(positive sequence)
b. susceptance (line
charging)
c. ratings (normal and
emergency)*
d. in-service status*
  5. DC Transmission systems
[TO]
  6. Transformer (voltage and
phase-shifting) [TO]
a. nominal voltages of
windings
b. impedance(s)
c. tap ratios (voltage or
phase angle)*
d. minimum and
maximum tap position
limits
e. number of tap positions
(for both the ULTC and
NLTC)
f. regulated bus (for
voltage regulating
transformers)*
g. ratings (normal and
emergency)*
h. in-service status*

necessary for modeling
purposes. [BA, GO, LSE, TO,
TSP]
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
Southwest Power Pool
Model Development Working Group
Charter
July 31, 2018

Purpose

The Model Development Working Group (MDWG) is responsible for the coordination, development, and maintenance of transmission system planning models in accordance with Southwest Power Pool (SPP) Planning Criteria, Regional Standards, and procedures. The MDWG is also responsible for supporting development of interconnection wide models by providing SPP transmission system planning models and related information to the Eastern Interconnection Reliability Assessment Group (ERAG) Multiregional Modeling Working Group (MMWG).

Scope of Activities

In carrying out its purposes, the MDWG will:

1. Provide oversight and coordination of the activities of MDWG-initiated task forces.

2. Develop and maintain the MDWG Model Development Procedure Manual.

3. Develop, maintain, and coordinate steady state, short circuit, dynamic, and geomagnetic disturbance models in accordance to the SPP Planning Criteria, SPP Regional Standards, and procedures.

4. Work with SPP Staff and the Transmission Working Group (TWG) to determine the models that should be used in SPP, basis for the models, and how they are modified to ensure that the transmission system planning models support the needs of SPP and SPP Organizational Groups.

5. Review and monitor existing and proposed NERC Reliability Standards for impacts to the development, maintenance, and coordination of SPP transmission system planning models. Coordinate responses to new and proposed standards with SPP and other SPP Organizational Groups.

6. Support the SPP submission of modeling data to the ERAG MMWG for the SPP transmission system. Coordinate the incorporation of ERAG MMWG modeling information for facilities external to the SPP transmission system into the SPP models.

7. Respond to assignments from the TWG, Markets and Operations Policy Committee (MOPC), or the Board of Directors.
Representation

The MDWG membership consists of a minimum of 8 and up to 24 representatives from the SPP membership, including the chair and vice-chair.

Duration

Permanent.

Reporting

The MDWG reports to the TWG. As necessary the MDWG may appoint a member of the MDWG as a liaison to other working groups.
Benchmarking Results & 2019 Build Recommendation

MDWG

December 6, 2018
Objective

- Compare fault responses from full eastern interconnection to reduced representation models
- Determine if there is continual need for full eastern interconnection models for future dynamic model builds
Benchmarking Participation

<table>
<thead>
<tr>
<th>Entities</th>
</tr>
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<tbody>
<tr>
<td>American Electric Power (AEP)</td>
</tr>
<tr>
<td>East Texas Electric Cooperative (ETEC) via GDS Associates</td>
</tr>
<tr>
<td>Evergy Companies (KCPL/WERE)</td>
</tr>
<tr>
<td>Grand River Dam Authority (GRDA)</td>
</tr>
<tr>
<td>Nebraska Public Power District (NPPD)</td>
</tr>
<tr>
<td>Oklahoma Gas &amp; Electric Company (OKGE)</td>
</tr>
<tr>
<td>Omaha Public Power District (OPPD)</td>
</tr>
<tr>
<td>City Utilities of Springfield (SPRM)</td>
</tr>
<tr>
<td>Southwestern Public Service Company (SPS)</td>
</tr>
<tr>
<td>Western Area Power Administration (WAPA)</td>
</tr>
</tbody>
</table>
Benchmarking Scope

• Transmission Planners (TP) provided up to 5 TPL contingencies.

• Staff utilized the 2018 SPP TPL dynamic assessment process and automation for this effort

• 2018 MDWG Model series 19L, 19S, and 28S full and reduced seasonal cases were utilized

• Staff processed TP provided contingencies and disturbance #1 and #2 from 2018 MDWG Dynamics Model Build
Benchmarking Scope

• Machine Channels:
  • ANGLE - Machine relative rotor angle
  • PELEC - machine electrical power
  • QELEC - machine reactive power
  • SPEED - machine speed deviation from nominal

• Bus Channels:
  • VOLT - Voltage magnitude in per unit
**Benchmarking Results**

<table>
<thead>
<tr>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamics data &amp; comparison plots</td>
</tr>
<tr>
<td>SPPR Plots</td>
</tr>
<tr>
<td>Voltage Scan Summary</td>
</tr>
<tr>
<td>Voltage Ride Through Scan</td>
</tr>
<tr>
<td>OS Relay Scan Summary</td>
</tr>
</tbody>
</table>
Benchmarking Results

• TP Provided Contingencies Results:
  • Posted to individual TP GlobalScape 2018 MDWG Dynamics Data Coordination Folders

• 2018 MDWG Dynamic Model Build Disturbance #1 & #2 Results:
  • Posted on GlobalScape: Modeling (CEII, RSD) ➔ MDWG Meetings ➔ MDWG ➔ 2018-12-6_Meeting_Material_Item2.zip
Benchmarking Results Summary

- Staff’s review observed results to be comparable for fault analysis.
  - For Frequency Response studies, Staff would recommend using full eastern interconnection models such as the MMWG models.
Staff Recommendation

- Staff recommends to build reduced models only for 2019 MDWG Dynamic model.
  - If MDWG identifies the need for full models, Staff would like to recommend limiting the number of full models to 2.
Recommendation

• The MDWG group recommends to build previously approved reduced models and two (20S and 20L) full models for 2019 MDWG Dynamic model set.
<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019 MDWG DYNAMICS MODELS</td>
<td>239 days</td>
</tr>
<tr>
<td>MMWG 2018 Series Dynamic Models</td>
<td>1 day</td>
</tr>
<tr>
<td>Receive ERAG MMWG SDDB (Dynamics Database)</td>
<td>1 day</td>
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<tr>
<td>Initial Data Update</td>
<td>40 days</td>
</tr>
<tr>
<td>Staff Send Unacceptable User Model List to Data Submitters</td>
<td>2 days</td>
</tr>
<tr>
<td>Initial Data Update - Build and Post DYRE Files, Wind Farm Data, and Docureport</td>
<td>2 days</td>
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<tr>
<td>Initial Data Update - Members Submit Data Updates</td>
<td>32 days</td>
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<tr>
<td>Initial Data Update - Member Data Due</td>
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<tr>
<td>Powerflow Adjustments</td>
<td>21 days</td>
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<tr>
<td>Powerflow Updates</td>
<td>10 days</td>
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<td>Wind Farm Topology</td>
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<tr>
<td>Initial Data Update - Member Data Due</td>
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<tr>
<td>Status Call</td>
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<tr>
<td>Dynamic Case Adjustments</td>
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<tr>
<td>Update SDDB (ERAG/MMWG Dynamic Database)</td>
<td>4 days</td>
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<tr>
<td>Duplicate Models</td>
<td>2 days</td>
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<tr>
<td>Generator Data Checks</td>
<td>2 days</td>
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<tr>
<td>SDDB Governor Limits and Small Time Constant Reset</td>
<td>2 days</td>
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<tr>
<td>WMOD/Generic WTG Checks</td>
<td>2 days</td>
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<tr>
<td>CONL &amp; GNET Files Updates</td>
<td>4 days</td>
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<tr>
<td>Post Member Feedback for Dynamic Data &amp; Case Issues</td>
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<td>Members Submit Data Updates</td>
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<tr>
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<tr>
<td>Process SPP Member Updates</td>
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<td>Dynamic Case Initialization</td>
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<td>Case &amp; Dyre File Corrections based on Initialization Messages</td>
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<tr>
<td>Build Final Models</td>
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<tr>
<td>20 Second No-fault Test &amp; Case Adjustment</td>
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<td>60 Second Ring-Down Test &amp; Case Adjustment</td>
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<tr>
<td>3-phase and SLG B&amp;C Faults Test &amp; Case Adjustment</td>
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<td>Dynamic Case Review and Finalization</td>
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<td>Post Initial Models</td>
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<td>Member Review of Initial Models</td>
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<td>Member Data Due</td>
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<tr>
<td>Data Update - Build Updated Models</td>
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<tr>
<td>Post Updated Models</td>
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<tr>
<td>Member Review of Final MDWG Dynamic Models</td>
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<tr>
<td>MDWG Finalization - Conference Call Vote</td>
<td>1 day</td>
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<tr>
<td>Data Update - Build Final Models including Board Decisions (NTC addition/withdrawals)</td>
<td>45 days</td>
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SECTION 1: INTRODUCTION

Purpose

This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, data owners, equipment, and data submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability

It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1)1 and the provisions of the

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1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-ERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

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2 Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

3 For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
- Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

- Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

- Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

- Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

- Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

- Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

### Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise,

5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement.
7 Equivalencing is a general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.
8 Sixth Revised Volume No.1, Attachment AI, Part II-1.
9 Sixth Revised Volume No.1, Attachment AI, Part II-2.
10 Sixth Revised Volume No.1, Part III-30.
11 Sixth Revised Volume No.1, Part III-31.
consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted. Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule ("schedule") jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes.** In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship

The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set

The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users

The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users

For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP. The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

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<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
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<td>3 Annual Summer Peak</td>
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<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
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The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the **Annual Models**
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission to data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

Data Transmittal
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- [GlobalScape](#)
2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the “SPP MDWG File Sharing Site”, [GlobalScape](#). Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

SPP Model Release Guidelines
**Steady-State and Short Circuit Models**
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If equivalized, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables
Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   Initialized steady state and regional contingency cases.
   a. Steady-State RAWD case file
   b. Conversion IDEV files

2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case

4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

Compliance

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

1. The Steady-State data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
**Table 1: Season Date Range and Cutoff Dates**

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

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**Load Forecast**

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be Non-Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models may not conform to a typical load duration curve and are typically modeled as non-scalable. These non-scalable loads are not affected during the allocation of the modeling area’s 50/50 load forecast to the individual load points.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand. DSM consists of controllable and non-controllable systems. Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. Distributed Energy Resources are power resources on the distribution system that can be aggregated together to provide power to meet Demand. For purposes of transmission
planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models. When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed agreement, or are in the process of finalizing a signed agreement should be included in the Data Submitter’s load forecast. SPP may reject any MOD projects or PSS®E idems that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Non-coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

**On-Peak/Off-Peak Models**

Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority coincident peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 85% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not the seasonal Summer On-Peak seasonal representation. The Summer Shoulder model, also known as the seasonal on-peak average model is defined to be 70% - 85% of the total Summer Peak load level depending on the Data Owner/Data Submitter system.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
</tbody>
</table>

Spring Peak (G): April 1st through May 31st
**Summer Peak (S):** June 1st through September 30th  
**Fall Peak (F):** October 1st through November 30th  
**Winter Peak (W):** December 1st through March 31st  
**Light Load (L):** April 1st through May 31st  
**Shoulder (SH):** 70% - 80% of Summer Peak model

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.

**Load Data**

Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The **Non-sScalable** Loads will be identified in the **Non-sScalable** Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the EDST.

**Area Summary Report**

The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary
Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.

4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.

5. An entity’s area slack machine shall be modeled within the entity’s model area.

6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.

7. The case year and season should be entered in the appropriate locations in chronological order.

8. The current system official load forecast should be entered as net load (Item 6).

9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.

10. Load equals net load minus estimated losses (Item 4).

11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

Tie Line Coordination
Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed.

This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

Line and Transformer Data
Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:
1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The “from bus,” “to bus”, and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance data shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be divided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each SPP member shall rate transmission circuits in accordance with the SPP Planning Criteria (Section 7.2). This criterion calls for each member to compute, at a minimum, summer and winter seasonal ratings for each circuit element. Each Base Case (Network) and Project branch, two-winding and three-winding transformer must have a specified rate A (normal) and rate B (long-term emergency) for spring, summer, fall, and winter. The ratings data format is in the MOD Procedure Manual.

6. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

7. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

8. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for
the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

9. Transformer connection codes\textsuperscript{12} and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

\textbf{Bus Data}

For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

\textbf{NOTE:} When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

\textsuperscript{12}Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
SPP Model Development Procedure Manual

1. For generator regulated buses, a desired voltage magnitude will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using a generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.

**Generator Data**

Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and Mbase limits per testing requirements in SPP Planning Criteria 7.1.1. Generator MW shall be set to “gross” level with auxiliary load modeled explicitly. Qmax and Qmin values in the models should be based on unit test data. Intermittent resources (e.g., wind and run-of-river hydro) should not normally be dispatched beyond their net capability as established by SPP Planning Criteria 7.1 for the summer and shoulder cases. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent
construction work, but is required for switching studies, fault analysis and dynamic simulation. For
dynamic simulation, this complex impedance must be set equal to the sub unsaturated
transient impedance for those generators modeled by sub transient level machine models,
and to transient impedance for those modeled by classical or transient level models. Machine Base
(MBASE) and Zero Impedance (ZSOURCE) values for the steady-state models must match dynamic
data. The MDWG steady-state models will use the saturated subtransient impedance data for
generators ($X''_{di}$). Future Generators that are in the models but are not budgeted for construction
need to be identified in the Generator Data worksheet of the EDST.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values
should be modeled as zero. Decommissioned units should be removed from the models.

### Modeling of Generator Parameters

1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV
and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

### Modeling Process for Generator Parameters

a. The Generator parameter P_{MAX} shall be modeled as a gross seasonal maximum
capability based on MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting
procedures.

b. Generating plant station service and auxiliary loads shall be represented in normal plant
configuration, corresponding to the load appropriate to operation of the generating
plant. All station service and auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus13,
      corresponding to the voltage to which the auxiliary load is
      served. Model representations of auxiliary load connected to
      the generating unit bus (Figure VII-1), auxiliary load
      modeled with separate transformation (Figure VII-2), and
      auxiliary load modeled on the high-side bus of the station
      service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

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13 Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a
unit with an amount corresponding to the plant auxiliary load.
c. Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

If generating plant station service and auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use “SS” in the Load ID field (Figure VII-4a). If there are more than one aggregated generating plant station service and auxiliary load, use “Sn” in the Load ID field to delineate the multiple aggregated loads.

If generating plant station service and auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “Fn” in the Load ID field to designate fixed load quantities that do not vary with plant dispatch.

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14 “n” represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
ii. Use "Vn" in the Load ID field to designate variable load quantities that do vary with plant dispatch.

Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).

d. The Generator Parameters for PMIN, AUX Load, QMAX, and QMIN shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

Modeling of Wind/Solar Renewable Resources $P_{GEN}$

- **Spring Light Load Off-Peak** models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility's latest five-year average (or replacement data if unavailable) for the SPP coincident Off-Peak hour corresponding to the season of the Light Load case, not to exceed each facility's firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility's long-term firm transmission service amount.

- **On-Peak & Summer Shoulder Off-Peak** models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility's latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility's firm service amount.

- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build.

- When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

- Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

- For resources that do not have firm service, $P_{GEN}$ values should not exceed average historical seasonal values for the Light Load Off-Peak, Spring On-Peak, Summer On-Peak, Spring Shoulder Off-Peak, Fall On-Peak, and Winter On-Peak models. If historical data is

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15 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

Data Exemption Process
MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the “Exemption Form” and send it via e-mail to “Engineering Modeling” containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

*Effective date of sections 1&3 is in effect.*
*Effective date of section 2 is July 1, 2016.*
*Effective date of section 4 is July 1, 2016.*

Shortfall Guidance Process
A shortfall is defined as an instance of insufficient firm resource to supply firm load. Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.
2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   e. The in-service date shall be based on the expected in-service date of the GI study.
   f. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).
   g. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
Remote Generation Modeling

Purpose

This procedure assures that members adhere to a uniform process when modeling remote generation in SPP.

Modeling Process

If a member acquires remote generation outside their Control Area (steady-state model numbered area), the following modeling process should be followed:

1. All buses should be assigned numbers that are in the host’s control area bus number range.
2. Area Number/Name should be the host’s control area number.
3. Zone Number/Name should be in the host’s control area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Owner Data and Line Mileage Data (SSAE Control)

To meet the SSAE requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:

1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. Area Interchange

The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. Tie Line Metering
The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (*summer On-Peak, Wwinter On-Peak, Llight Load Off-Peak*).

4. **Network**
   Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
   The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**
      Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.
Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. Summary of Overloaded Branches
This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. Generation Summary
All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST. The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

- QT --- MAX = one-half of MW rating
- QB --- MIN = negative one-third of MW rating

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.
The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in “free format” with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data
for that bus will be removed (e.g., branches, transformers, generators, and loads). **The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified.** Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have "Area interchange control" with the "Tie Line and Loads" option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**Steady-State Modeling Requirements**

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.
3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be
given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the Xsource value in the steady-state generator data record shall be as follows:
   a. Xsource = X''d for detailed synchronous machine modeling
   b. Xsource = X'd for non-detailed synchronous machine modeling
   c. Xsource = should be equal to locked rotor impedance for an induction machine
   d. Xsource = 1.0 per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E dynamic library models compatible with either representation are available. If a user model representing particular SVC and control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV.

   Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

   If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to "load net" (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using R=0.00000 + X=0.0001 and B=0.00000. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of R=0.0001 + X=0.002 and B=0.00000. This allows
use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – Effective with Revision 28 of PSS®E, off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding. The measured impedance (resistive and inductive) between each pair of windings shall be specified: data entry options permit these to be entered in (1) per unit on system (100 MVA) base, (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage.

9. Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

10. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

11. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes. PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:
   a. Real-time operational auto or manual adjustment operation of the PST.
   b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer On-Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
   c. Real-time operational MW flow limits (e.g. ±20 MW).
   d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
   e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
   f. Applicable long-term firm transmission service levels for the PST.
12. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

13. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

14. Out-of-Service Generator Modeling – Out-of-service generators should be modeled with a STATUS equal to zero.

15. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

17. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

18. Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.
19. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

20. Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

21. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

22. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

23. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point and equipment status, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation.

24. HVDC – All HVDC transmission facilities must be represented with a sufficiently detailed model to simulate its expected behavior.

25. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

26. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it. (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during equivalencing.

4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.
5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. Fictitious regulation of buses.

12. Extremely low voltage schedules.

13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting under load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area. While typically analogous to a

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$^{16}$ The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

$^{17}$ Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\(^{18}\) loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

![Figure 1. Example of interconnected model areas.](image)

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\(^{18}\) ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch ($P_{gen}$) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as "transactions" and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. Therefore, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

---

**Inter-area Bilateral transaction description**

Data Owner A exports MW to Data Owner B  
Data Owner B imports MW from Data Owner A

**Transaction accounting in Data Submittal Workbook**

<table>
<thead>
<tr>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>Data Source MDWG Model - MSG</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>Data Owner B</td>
<td>ABC123</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>Data Owner A</td>
<td>ABC123</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
<td></td>
</tr>
</tbody>
</table>

---

Figure 3. Example of Inter-area transfer (transaction).
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

**Transaction Update**

The transaction workbook should be updated to show a transaction from the control area where remote generation is located to the generation owner control area. If the remote generation is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area’s number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

**No Transaction Needed**
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

**Transaction Needed**
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic Models include full MMWG cases and machine reduced cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model Update is used to support SPP reliability studies and ERAG MMWG Dynamic model requirements. It is important for all generating entities that interconnect to the SPP transmission to support the Regional Transmission Organization with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic Model Format is PSS®E dynamics DYRE and RAWD formats.

The Dynamics Model data includes:
1. Steady-State models
2. Dynamics model data in Siemens PTI PSS®E DYRE format
3. User written model source and object code (includes wind farms)
4. ERAG MMWG System Dynamics Database (SDDB)
5. SDDB data update worksheet

SPP MDWG Dynamic Models are published according to the schedule in Section 15 B.

1. The Dynamic data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Dynamics Model is also updated annually with current generator unit information. Steady-State models are used in conjunction with dynamic data to run dynamic simulation.

Procedures for Initialization and No-Disturbance Checks Of Library DYNAMICS Cases

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or –9999.
   c. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]

vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.

viii. Branches with extreme impedances or tap ratios [BRCH].
Suggested options are:

a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.

b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.

c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.

d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE].
Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]

c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE]

e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]
3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].
4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]
5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)
   a. Specify CONEC, CONET, and COMPILE files.
   b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.
6. Concatenate FLECS code for user models onto CONEC or CONET files.
7. Compile.
9. Restart from the dynamics entry point, this time using "user dynamics".
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE]
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN].
      Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.
      ii. A tabulation of conditions at each online machine
         a) Terminal voltage
         b) Exciter output voltage
         c) Real and reactive power output
         d) Power factor
         e) Machine angle in degrees
         f) Direct and quadrature axis currents on machine base.
      iii. A diagnosis of initial conditions, either
         a) "Initial conditions check OK", or
         b) A listing of suspect initial conditions generally states whose time derivative is not "small" (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.
         iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.
   f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.
10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.
11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN, CM] can indicate where problems are, but considerably increases the amount of output.
12. Stop simulation. Review output values in tabular and/or graphical form.
13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).
14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately $\frac{-1}{R}$, mechanical power to $(1 - \frac{1}{K})$ times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Dynamic Data Format

**PSS®E Users**
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

**Non-PSS®E Users**
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

NERC maintains a list of acceptable dynamic models on the NERC website for reference by the GO. Only NERC acceptable dynamic models from the latest approved list shall be provided the applicable TPs and to SPP, as PC, for dynamic model building purposes. The acceptable dynamic model list can be found on the [NERC SAMS website](http://www.nerc-sams.org) > NERC Acceptable Model List.

Dynamic models that are considered unacceptable by NERC, shall be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.
Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP

**Dynamics Data Submittal Requirements and Guidelines**

1. **All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below.** Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The PSS®E dynamic model types classified as detailed are GENROU, GENSAL, GENROE, GENSAE, and GENDCO.

   The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.

   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.

   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. **All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry.** The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
   c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
   d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. **All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.**
4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

   Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

Dynamics Data Validation Requirements
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.
### Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).

2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

### Procedures for Submission of Dynamics Data to the MMWG Coordinator

Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

#### Dynamics Data Updates Using Excel Template

Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.

The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another model of the same equipment group</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes for new model.</td>
<td>1. A DC exciter is replaced by a static exciter. 2. A classical machine model is replaced by a detailed model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all models of an existing unit</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>
Complete Set of Dynamics Data

The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

System Dynamic Data Base and Dynamic Simulation Cases

SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

1. The Short Circuit data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data. The sequence data is comprised of positive, zero, and negative sequence data. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final). The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the Reliability Steady-State models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be
built:
1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:
1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:
1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:
1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions
SECTION 6: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#, 
From Area Name,
From Bus#, 
From Bus Name, 
From Bus kV,
To Region Name, 
To Area#, 
To Area Name, 
To Bus#, 
To Bus Name, 
To Bus kV,
Metered End (F,T),
CKT, 
R, 
X, 
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI (pu),
BI (pu),
GJ (pu),
BJ (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS {0,1},
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RMI1,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

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<td>Winding 2 Bus kV,</td>
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Three Winding Transformer Data Fields - continued

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<td>WindV2</td>
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<td>Summer Rating C2</td>
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<tr>
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Three Winding Transformer Data Fields - continued

RM12,
VMA2,
VM12,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RM13,
VMA3,
VM13,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields

- In Service Date,
- Out Service Date,
- I,
- MDC,
- RDC,
- SETVL,
- VSCHD,
- VCMOD (1,0),
- RCOMP,
- DELTI,
- METER (R,I),
- DCVMIN,
- CCCITMX,
- CCCACC,
- IPR REGION NAME,
- IPR AREA#,
- IPR AREA NAME,
- IPR Bus#,
- IPR BUS NAME,
- IPR BUS Kv,
- NBR,
- ALFMX,
- ALFMN,
- RCR,
- XCR,
- EBASR,
- TRR,
- TAPR,
- TMXR,
- TMNR,
- STPR,
- ICR REGION NAME,
- ICR AREA#,
- ICR AREA NAME,
- ICR BUS#,
- ICR BUS NAME,
- ICR BUS kV,
- IFR REGION NAME,
- IFR AREA#,
- IFR AREA NAME,
- IFR BUS#,
- IFR BUS NAME,
- IFR BUS kV,
- ITR REGION NAME,
- ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAFR,
IPI REGION NAME,
IPI AREA#, 
IPI AREA NAME,
IPI Bus#, 
IPI BUS NAME,
IPI BUS Kv,
NBI,
GAMMX,
GAMMN,
RCI,
XCI,
EBASI,
TRI,
TAPI,
TMXI,
TMNI,
STPI,
ICI REGION NAME,
ICI AREA#, 
ICI AREA NAME,
ICI BUS#, 
ICI BUS NAME,
ICI BUS Kv,
IFI REGION NAME,
IFI AREA#, 
IFI AREA NAME,
IFI BUS#, 
IFI BUS NAME,
IFI BUS Kv,
ITI REGION NAME,
ITI AREA#, 
ITI AREA NAME,
ITI BUS#, 
ITI BUS NAME,
ITI BUS KV,
IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements. 
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
### SECTION 7: APPENDIX III

**UTILIZED IMPEDANCE CORRECTION TABLES**

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## SECTION 8: MOD-032-1 ATTACHMENT 1

**MOD-032-1 – ATTACHMENT 1**

The table below indicates the information that is required to effectively model the interconnected transmission system for the Near Term Transmission Planning Horizon and Long Term Transmission Planning Horizon. Data must be shareable on an interconnectionwide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity1 responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

### steady-state

(Items marked with an asterisk indicate data that vary with system operating state or conditions. These items may have different data provided for different modeling scenarios)

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<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
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<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
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<td>a. nominal voltage</td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>a. Positive Sequence Data</td>
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<tr>
<td>b. area, zone and owner</td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>b. Negative Sequence Data</td>
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<td>a. real and reactive power*</td>
<td>5. Demand [LSE]</td>
<td>2. Mutual Line Impedance Data [TO]</td>
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<td>b. in-service status*</td>
<td>6. Wind Turbine Data [GO]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
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<td>3. Generating Units 20 [GO, RP (for future planned resources only)]</td>
<td>7. Photovoltaic systems [GO]</td>
<td>10. Other information requested by the Planning Coordinator or Transmission Planner</td>
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<td>a. real power capabilities - gross maximum and minimum values</td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
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<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td>9. DC system models [TO]</td>
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<td>c. station service auxiliary load for normal plant configuration (provide data in the same row)</td>
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19 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
manner as that required for aggregate Demand under item 2, above).

d. regulated bus* and voltage set point* (as typically provided by the TOP)
e. machine MVA base
f. generator step up transformer data (provide same data as that required for transformer under item 6, below)
g. generator type (hydro, wind, fossil, solar, nuclear, etc)
h. in-service status*

4. AC Transmission Line or Circuit [TO]
   a. impedance parameters (positive sequence)
   b. susceptance (line charging)
   c. ratings (normal and emergency)*
   d. in-service status*

5. DC Transmission systems [TO]

6. Transformer (voltage and phase-shifting) [TO]
   a. nominal voltages of windings
   b. impedance(s)
   c. tap ratios (voltage or phase angle)*
   d. minimum and maximum tap position limits
   e. number of tap positions (for both the ULTC and NLTC)
   f. regulated bus (for voltage regulating transformers)*
   g. ratings (normal and emergency)*
   h. in-service status*
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
<table>
<thead>
<tr>
<th>Task Name</th>
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<tr>
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<td><strong>Pass 1 - Load and Generation Profiles/Transactions</strong></td>
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<td>Pass 1 - SPP Staff compile and conduct interchange conference calls</td>
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<td><strong>Pass 2: Incorporate Load and Generation Profiles/Transactions</strong></td>
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<td><strong>Pass 3 (Generation, Loads, &amp; Interchange Updates)</strong></td>
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<td>Pass 3 - SPP Staff Reviews/Builds Pass 3 Solved models (Merge with MMWG Current or Prior year)</td>
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### 2019 MDWG Power Flow Finalization

Final - Lock Down MOD
Final - SPP Staff Reviews/Builds Final Powerflow Models

#### Stakeholders Review for Finalization of the 2019 Series MDWG Powerflow Models

**Finalization - Conference Call Vote**

#### 2019 MDWG Short Circuit Models

Merge with SERC Short Circuit Models
Pass 1 - SPP Staff Posts Pass 1 for Stakeholder review
Pass 2 - SPP Staff Posts Pass 2 for Stakeholder review
Pass 3 - SPP Staff Posts Pass 3 for Stakeholder review

#### 2019 MDWG Short Circuit Model Finalization

Stakeholders Review for Finalization of the 2019 Series MDWG Short Circuit Models

**Finalization - Conference Call Vote**

### 2019 Series MDWG / 2020 ITP Model Selection

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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, data owners, equipment, and data submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator's planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC's Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1)1, and the provisions of the

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1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners:\(1\) of equipment within the SPP Planning Coordinator planning area and/or equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

**Applicable Data Submitters**

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise,

5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Equivalencing is a general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.
8 Sixth Revised Volume No.1, Attachment AI, Part II-1.
9 Sixth Revised Volume No.1, Attachment AI, Part II-2.
10 Sixth Revised Volume No.1, Part III-30.
11 Sixth Revised Volume No.1, Part III-31
consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted. Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule ("schedule") jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- Appropriate lead times. Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes. In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.
The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

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<td>8 Annual + 1 Summer Shoulder</td>
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The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models.
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission to data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

**Data Transmittal**

Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- GlobalScape
2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the "SPP MDWG File Sharing Site", GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP Model Release Guidelines**

**Steady-State and Short Circuit Models**

SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If equivalized, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables
Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   Initialized steady state and regional contingency cases.
   a. Steady-State RAWD case file
   b. Conversion IDEV files

2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

**NOTE** – A complete listing of other SPP acronyms can be found on the SPP website at [SPP Glossary](#).

Compliance

1. MDWG [Model Development Procedure Manual](#)  
   Note: The latest document can be found on SPP.org

2. MDWG [Power flow, Short Circuit, and Dynamic model schedule and list](#)  
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)  
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

1. The Steady-State data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, outages, long name, and associated auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be Non-Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models may not conform to a typical load duration curve and are typically modeled as non-scalable. These non-scalable loads are not affected during the allocation of the modeling area’s 50/50 load forecast to the individual load points.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand. DSM consists of controllable and non-controllable systems. Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. Distributed Energy Resources are power resources on the distribution system that can be aggregated together to provide power to meet Demand. For purposes of transmission
planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed agreement, or are in the process of finalizing a signed agreement should be included in the Data Submitter’s load forecast. SPP may reject any MOD projects or PSS®E idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Non-coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

**On-Peak/Off-Peak Models**

Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority coincident peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td></td>
<td>Typically 70% - 80% of Summer On-Peak load level</td>
</tr>
</tbody>
</table>

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for
planning model building purposes.

Load Data
Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the EDST.

Area Summary Report
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.
12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**
Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed.

This coordination should consist of:
1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie's steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**
Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.
2. The "from bus," “to bus”, and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The "from bus" is assumed to be the metered end (unless the "to bus" is entered with a negative) and the "to bus" area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer...
(LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance data parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be divided provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter SPP member shall submit normal and emergency ratings for a transmission circuit in accordance with the SPP Planning Criteria (Section 7.2). This criterion calls for each member to compute, at a minimum, summer and winter seasonal ratings for each circuit element. Each Base Case (Network) and Project branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal continuous) and rate B (long-term emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional spring, summer, fall, and winter. The ratings data format is in the MOD Procedure Manual.

6. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

7. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

8. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.
9. Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

Bus Data
For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code describe what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

NOTE: When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

- 1 - Below 69 kV
- 4 - 138 kV
- 7 - 345 kV
- 2 - 69 kV
- 5 - 161 kV
- 8 - 500 kV

12 Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
1. For generator regulated buses, a desired voltage setpoint will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using generator for voltage support only (i.e., no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.

**Generator Data**

Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per testing requirements in SPP Planning Criteria 7.1.1. Generator real power MW capability shall be set to the gross maximum and minimum values (PMAX and PMIN) level with auxiliary load modeled explicitly. Qmax and Qmin Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities. Intermittent resources (e.g., wind and run-of-river hydro) should not normally be dispatched beyond their net capability as established by SPP Planning Criteria 7.1 for the summer and shoulder cases. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no
greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the sub unsaturated transient impedance for those generators modeled by sub transient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Zero Impedance (ZSOURCE, ZR + jZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X''di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.

**Modeling of Generator Parameters**

1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

**Modeling Process for Generator Parameters**

a. The Generator parameter P_{MAX} shall be modeled as a gross seasonal maximum capability based on MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

b. Generating plant station service and auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All station service and auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus\(^{13}\), corresponding to the voltage to which the auxiliary load is served. Model representations of auxiliary load connected to the generating unit bus (Figure VII-1), auxiliary load modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

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\(^{13}\) Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the P_{gen} of a unit with an amount corresponding to the plant auxiliary load.
c. Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

If generating plant station service and auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use "SS" in the Load ID field (Figure VII-4a). If there are more than one aggregated generating plant station service and auxiliary load, use "Sn" in the Load ID field to delineate the multiple aggregated loads.

If generating plant station service and auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant $P_{gen}$ may be less than $P_{max}$) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use "Fn" in the Load ID field\(^{14}\) to designate fixed load quantities that do not vary with plant dispatch.

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\(^{14}\) "n" represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
ii. Use "Vn" in the Load ID field to designate variable load quantities that do vary with plant dispatch.

Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).

- Aggregated Auxiliary Load “SS”
- Combined Auxiliary Load (Fixed portion) “F1”
- Combined Auxiliary Load (Variable portion) “V1”
- Discrete Station Heater Auxiliary Load (Fixed) “F2”
- Discrete Fuel Auger Auxiliary Load (Variable) “V2”
- Discrete Station Lighting Auxiliary Load (Fixed) “F2”
- Discrete Effluent Pump Auxiliary load (Variable) “V2”

Modeling of Wind/Solar Renewable Resources $P_{GEN}$

- **Spring Light Off-Peak** models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP coincident Off-Peak hour corresponding to the season of the Light Load case, not to exceed each facility’s firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

- On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility’s firm service amount.

- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build.

- When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

- Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

- For resources that do not have firm service, $P_{GEN}$ values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net

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15 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

**Data Exemption Process**

MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the "Exemption Form" and send it via e-mail to "Engineering Modeling" containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.**

**Effective date of section 2 is July 1, 2016.**

**Effective date of section 4 is July 1, 2016.**

**Shortfall Guidance Process**

A shortfall is defined as an instance of insufficient firm resource to supply firm load. Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.
   
2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   e. The in-service date shall be based on the expected in-service date of the GI study.
   f. In order to identify future GI queued generation, the unit name shall be the GI gen number [e.g. GEN-2017-898] and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).
   g. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
d. The addition of exploratory generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

Remote Generation Modeling

Purpose
This procedure assures that members adhere to a uniform process when modeling remote generation in SPP.

Modeling Process
If a member acquires remote generation outside their Control Area (steady-state model numbered area), the following modeling process should be followed:
1. All buses should be assigned numbers that are in the host's control area bus number range.
2. Area Number/Name should be the host's control area number.
3. Zone Number/Name should be in the host's control area zone range.
4. Generation Owner Number should be the owner's designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Owner Data and Line Mileage Data (SSAE Control)

To meet the SSAE requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:
1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. Area Interchange
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. Tie Line Metering
The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. Area Totals
The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads.

The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. Network
Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. Review of Output
The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. Three useful reports for locating problems include:
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. Voltage Summaries
   Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.
Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

1. QT --- MAX = one-half of MW rating
2. QB --- MIN = negative one-third of MW rating

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.
The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in “free format” with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data
for that bus will be removed (e.g., branches, transformers, generators, and loads). **The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified.** Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have “Area interchange control” with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**Steady-State Modeling Requirements**

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.
3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be
given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the Xsource value in the steady-state generator data record shall be as follows:
   a. Xsource = X''d for detailed synchronous machine modeling
   b. Xsource = X'd for non-detailed synchronous machine modeling
   c. Xsource should be equal to locked rotor impedance for an induction machine
   d. Xsource = 1.0 per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E dynamic library models compatible with either representation are available. If a user model representing particular SVC and control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using R=0.00000 + X=0.0001 and B=0.00000. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of R=0.0001 + X=0.002 and B=0.00000. This allows
use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – Effective with Revision 28 of PSS®E, off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding. The measured impedance (resistive and inductive) between each pair of windings shall be specified: data entry options permit these to be entered in (1) per unit on system (100 MVA) base, (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage.

9. Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

10. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

11. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes.

    PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:
    a. Real-time operational auto or manual adjustment operation of the PST.
    b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
    c. Real-time operational MW flow limits (e.g. ±20 MW).
    d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
    e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
    f. Applicable long-term firm transmission service levels for the PST.
12. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

13. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

12.14 Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

13.15 Out-of-Service Generator Modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

14.16 Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

15.17 Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16.18 Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

17.19 Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple
buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

18.20 Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

19.21 Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

20.22 Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

21.23 Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

22.24 Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point and equipment status, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation.

23.25 HVDC Transmission Systems – All HVDC transmission facilities must be represented with a sufficiently detailed model to simulate its expected behavior.

24.26 Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

25.27 Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it. (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)
2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.
3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during equivalencing.
4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.
5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.
6. Unrealistic tap changing transformer tap limits.
7. Radial system is very large.
8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.
10. Not solvable from flat start.
11. Fictitious regulation of buses.
12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.
14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.
15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling\textsuperscript{16} is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of buses representing a model area\textsuperscript{17}. While typically analogous to a

\textsuperscript{16} The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

\textsuperscript{17} Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\textsuperscript{18} loads and induction machine loads to be assigned to model areas that may be different than the buses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

\begin{figure}
\centering
\includegraphics[width=\textwidth]{model_area_diagram.png}
\caption{Example of interconnected model areas.}
\end{figure}

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\textsuperscript{18}ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (Pgen) of each non-sack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as "transactions" and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-member), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

### Inter-area Bilateral transaction description

**Data Owner A exports MW to Data Owner B**

**Data Owner B imports MW from Data Owner A**

### Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>Data Series MDWG Model - 1GS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>Nit SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

*Figure 3. Example of Inter-area transfer (transaction).*
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

**Transaction Update**
The transaction workbook should be updated to show a transaction from the control area where remote generation is located to the generation owner control area. If the remote generation is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area's number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

- **No Transaction Needed**
  - Source Area: XXX
  - Sink Area: YYY
  - Sink Load: XXX

- **Transaction Needed**
  - Source Area: XXX
  - Sink Area: YYY
  - Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC's ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic Models include full MMWG cases and machine reduced cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model Update is used to support SPP reliability studies and ERAG MMWG Dynamic model requirements. It is important for all generating entities that interconnect to the SPP transmission to support the Regional Transmission Organization with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic Model Format is PSS®E dynamics DYRE and RAWD formats.

The Dynamics Model data includes:

1. Steady-State models
2. Dynamics model data in Siemens PTI PSS®E DYRE format
3. User written model source and object code (includes wind farms)
4. ERAG MMWG System Dynamics Database (SDDB)
5. SDDB data update worksheet

SPP MDWG Dynamic Models are published according to the schedule in Section 15 B.

1. The Dynamic data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Dynamics Model is also updated annually with current generator unit information. Steady-State models are used in conjunction with dynamic data to run dynamic simulation.

Procedures for Initialization and No-Disturbance Checks Of Library DYNAMICS Cases

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or −9999.
   c. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]

vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.

viii. Branches with extreme impedances or tap ratios [BRCH].

Suggested options are:

  a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.

  b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.

  c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.

  d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

  e) High tap ratios.

  f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.

  i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

     ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

     iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

  iv. Buses in “islands” not containing a system swing bus. [TREE].

  

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

  a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

  b. Read in the raw data file just created. [READ]

  c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

  d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE]

  e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]
3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)
   a. Specify CONEC, CONET, and COMPILE files.
   b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using "user dynamics".
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE]
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN].
      Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.
      ii. A tabulation of conditions at each online machine
         a) Terminal voltage
         b) Exciter output voltage
         c) Real and reactive power output
         d) Power factor
         e) Machine angle in degrees
         f) Direct and quadrature axis currents on machine base.
      iii. A diagnosis of initial conditions, either
         a) "Initial conditions check OK", or
         b) A listing of suspect initial conditions generally states whose time derivative is not "small" (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.
         iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems.
            This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.
   f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.
10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((-K) = -1 / R\), mechanical power to \((1-1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

**Dynamic Data Format**

**PSS®E Users**

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalEscape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

**Non-PSS®E Users**

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

NERC maintains a list of acceptable dynamic models on the NERC website for reference by the GO. Only NERC acceptable dynamic models from the latest approved list shall be provided the applicable TPs and to SPP, as PC, for dynamic model building purposes. The acceptable dynamic model list can be found on the [NERC SAMS website](#)™ Reference Materials > NERC Acceptable Model List.

Dynamic models that are considered unacceptable by NERC, shall be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.
Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP

**Dynamics Data Submittal Requirements and Guidelines**

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The PSS®E dynamic model types classified as detailed are GENROU, GENSAL, GENROE, GENSAE, and GENDCO.

   The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.

   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.

   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
   c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
   d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.
4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

   Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

Dynamics Data Validation Requirements
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.I* of this manual (*yet to be written) may be applied for this purpose.
Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).

2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator

Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template

Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.

The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another model of the same equipment group</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes for new model.</td>
<td>1. A DC exciter is replaced by a static exciter. 2. A classical machine model is replaced by a detailed model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all models of an existing unit</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

---

52
<table>
<thead>
<tr>
<th>Change bus number</th>
<th>No</th>
<th>No</th>
<th>Maintain the same name and unit ID and the model data will follow automatically.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
<td>Same requirements whether unit is at new or existing bus.</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Complete Set of Dynamics Data**

The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**

SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA
REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

1. The Short Circuit data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data. The sequence data is comprised of positive, zero, and negative sequence data. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final). The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the Reliability Steady-State models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be
The Base MDWG Short Circuit models are built by performing the following steps:
1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:
1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:
1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions
SECTION 6: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

- In Service Date,
- Out Service Date,
- From Region Name,
- From Area#,
- From Area Name,
- From Bus#,
- From Bus Name,
- From Bus kV,
- To Region Name,
- To Area#,
- To Area Name,
- To Bus#,
- To Bus Name,
- To Bus kV,
- Metered End (F,T),
- CKT,
- R,
- X,
- B,
- Summer Rating A,
- Summer Rating B,
- Summer Rating C,
- Winter Rating A,
- Winter Rating B,
- Winter Rating C,
- GI (pu),
- BI (pu),
- GJ (pu),
- BJ (pu),
- STATUS (0,1),
- LEN (mi),
- Owner 1,
- Fraction 1,
- Owner 2,
- Fraction 2,
- Owner 3,
- Fraction 3,
- Owner 4,
- Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area #,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area #,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM11,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#,
Winding 1 Area Name,
Winding 1 Bus#,
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#,
Winding 2 Bus Name,
Winding 2 Bus Area Name,
Winding 2 Bus #,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#,
Winding 3 Area Name,
Winding 3 Bus#,
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBase2-3,
R3-1,
Three Winding Transformer Data Fields - continued

X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus #(CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RMI1,
VMA1,
VM1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued

RM12,
VMA2,
VM12,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RMI3,
VMA3,
VM13,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields

In Service Date, Out Service Date, I, MDC, RDC, SETVL, VSCHD, VCMOD (1,0), RCOMP, DELTI, METER (R,I), DCVMIN, CCCITMX, CCCACC, IPR REGION NAME, IPR AREA#, IPR AREA NAME, IPR Bus#, IPR BUS NAME, IPR BUS Kv, NBR, ALFMX, ALFMN, RCR, XCR, EBASR, TRR, TAPR, TMXR, TMNR, STPR, ICR REGION NAME, ICR AREA#, ICR AREA NAME, ICR BUS#, ICR BUS NAME, ICR BUS kV, IFR REGION NAME, IFR AREA#, IFR AREA NAME, IFR BUS#, IFR BUS NAME, IFR BUS kV, ITR REGION NAME, ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS#,  
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAPR,
IPI REGION NAME,
IPI AREA#,  
IPI AREA NAME,
IPI Bus#,  
IPI BUS NAME,
IPI BUS KV,
NBI,
GAMMX,
GAMMN,
RCI,
XCI,
EBASI,
TRI,
TAPI,
TMXI,
TMNI,
STPI,
ICI REGION NAME,
ICI AREA#,  
ICI AREA NAME,
ICI BUS#,  
ICI BUS NAME,
ICI BUS KV,
IFI REGION NAME,
IFI AREA#,  
IFI AREA NAME,
IFI BUS#,  
IFI BUS NAME,
IFI BUS KV,
ITI REGION NAME,
ITI AREA#,  
ITI AREA NAME,
ITI BUS#,  
ITI BUS NAME,
ITI BUS KV,
IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.  
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
### Utilized Impedance Correction Tables

| Table Number | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor |
|--------------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|
| 1            | -60          | 1      | -56          | 0.99   | -24.4        | 1.462  | -12.4        | 0.636  | -6.3         | 0.362  | 12.4         | 0.636  | 24.4         | 1.462  | 56          | 0.358  | 60          | 0.358  |
| 2            | -70          | 1.43   | -72          | 0.68   | 0            | 0.12   | 32           | 0.58   | 70           | 0      | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 3            | -110         | 1      | -150         | 0.5    | 0            | 0.15   | 100          | 1      | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 4            | -152         | 0.275  | -182.5       | 0.625  | -42.2        | 0.217  | 0            | 0.175  | 42.2         | 0.217  | 53.4         | 0.375  | 121.5        | 0.635  | 152         | 1      | 0            | 0      |
| 5            | -40          | 1.946  | -38          | 1.406  | 0            | 0      | 50           | 1.102  | 80           | 0      | 120          | 0      | 200          | 0      | 0            | 0      |
| 6            | -25          | 1.395  | 0            | 1.395  | 0            | 0      | 25           | 1.395  | 0            | 0      | 0            | 0      | 0            | 0      |
| 7            | -25          | 1.395  | 0            | 1.395  | 0            | 0      | 25           | 1.395  | 0            | 0      | 0            | 0      | 0            | 0      |
| 8            | -40          | 0.36   | -29.5        | 0.715  | -20.6        | 0      | 21.5         | 0.515  | 29.5         | 0      | 41.5         | 0      | 61.5         | 0      | 81.5         | 0      | 0            | 0      |
| 9            | -40          | 1.849  | -30          | 1.575  | 0            | 0      | 20           | 1.125  | 30           | 1.575  | 40           | 1.775  | 60           | 0      | 0            | 0      |
| 10           | -25          | 1.995  | 0            | 1.995  | 0            | 0      | 25           | 1.995  | 0            | 0      | 0            | 0      | 0            | 0      |
| 11           | -25          | 1.995  | 0            | 1.995  | 0            | 0      | 25           | 1.995  | 0            | 0      | 0            | 0      | 0            | 0      |
| 12           | -40          | 0.36   | -29.5        | 0.715  | -20.6        | 0      | 21.5         | 0.515  | 29.5         | 0      | 41.5         | 0      | 61.5         | 0      | 81.5         | 0      | 0            | 0      |
| 13           | -40          | 1.849  | -30          | 1.575  | 0            | 0      | 20           | 1.125  | 30           | 1.575  | 40           | 1.775  | 60           | 0      | 0            | 0      |
| 16           | -30          | 1.913  | 0            | 1.913  | 0            | 0      | 30           | 1.913  | 0            | 0      | 0            | 0      | 0            | 0      |
| 17           | -47          | 0.84   | -13.6        | 2.096  | 0.679        | 0      | 1.59         | 1.627  | 1.39         | 0.747  | 2.199        | 1.927  | 3.039        | 1.667  | 0.779        | 1.217  |
| 18           | -40          | 2.31   | 0            | 2.31   | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 19           | -40          | 2.31   | 0            | 2.31   | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 21           | 0.909        | 0.797  | 1.04         | 1.23   | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 22           | 0.6          | 1.935  | 0.83         | 1.358  | 0.929        | 0.75   | 1.59         | 1.398  | 1.398        | 0.75   | 1.59         | 1.398  | 1.398        | 0.75   | 1.59         |
| 23           | -10          | 1      | 1.04         | 1.04   | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 24           | 0.759        | 1.641  | 1.01         | 1.01   | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 25           | -60          | 9.2    | -46.2        | 4.69   | -32.2        | 1.87   | -28          | 1.12   | -18          | 1      | -12.5        | 0.85   | -7.5         | 0.55   | 12.5         | 0.85   |
| 31           | -15          | 2.076  | 0            | 2.076  | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 32           | -15          | 2.076  | 0            | 2.076  | 0            | 0      | 0            | 0      | 0            | 0      | 0            | 0      |
| 42           | 0.959        | 1.852  | -32.8        | 1.497  | -22.3        | 1.07   | -11.1        | 0.85   | -11.1        | 0.85   | -22.3        | 1.07   | -32.8        | 1.497  |
| 44           | 0.524        | 1.024  | -43.6        | 1.678  | -33.1        | 1.403  | -23.2        | 1.228  | -12.1        | 1      | -1.2         | 1.168  | 9.9          | 1.276  | 20.9         | 1.418  | 33.4         | 1.559  | 60          |

SPP Model Development Procedure Manual
**SECTION 8: MOD-032-1 ATTACHMENT 1**

**MOD-032-1 – ATTACHMENT 1**

The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnectionwide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

- **steady-state**
  - (Items marked with an asterisk indicate data that vary with system operating state or conditions. These items may have different data provided for different modeling scenarios)

- **dynamics**
  - (If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)

- **short circuit**

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Items marked with an asterisk indicate data that vary with system</td>
<td>(If a user-written model(s) is submitted in place of a generic or library</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>operating state or conditions. These items may have different data</td>
<td>model, it must include the characteristics of the model, including block</td>
<td>1. Positive Sequence Data</td>
</tr>
<tr>
<td>provided for different modeling scenarios)</td>
<td>diagrams, values and names for all model parameters, and a list of all</td>
<td>1. Negative Sequence Data</td>
</tr>
<tr>
<td></td>
<td>state variables)</td>
<td>1. Zero Sequence Data</td>
</tr>
<tr>
<td>1. Each bus [TO]</td>
<td></td>
<td>2. Mutual Line Impedance Data [TO]</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td></td>
<td>3. Other information requested by the Planning Coordinator or Transmission</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td></td>
<td>Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>2. Aggregate Demand[19] [LSE]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. in-service status*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Generating Units[20] [GO, RP (for future planned resources only)]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real</td>
<td></td>
<td></td>
</tr>
<tr>
<td>power capabilities in 3a above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide</td>
<td></td>
<td></td>
</tr>
<tr>
<td>data in the same manner as that</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

19 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
<table>
<thead>
<tr>
<th>Required for aggregate Demand under item 2, above.</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
</tr>
<tr>
<td>e. machine MVA base</td>
</tr>
<tr>
<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
</tr>
<tr>
<td>g. generator type [hydro, wind, fossil, solar, nuclear, etc]</td>
</tr>
<tr>
<td>h. in-service status*</td>
</tr>
</tbody>
</table>

4. AC Transmission Line or Circuit [TO]
   a. impedance parameters (positive sequence) |
   b. susceptance (line charging) |
   c. ratings (normal and emergency)* |
   d. in-service status* |

5. DC Transmission systems [TO] |

6. Transformer (voltage and phase-shifting) [TO] |
   a. nominal voltages of windings |
   b. impedance(s) |
   c. tap ratios (voltage or phase angle)* |
   d. minimum and maximum tap position limits |
   e. number of tap positions (for both the ULTC and NLTC) |
   f. regulated bus (for voltage regulating transformers)* |
   g. ratings (normal and emergency)* |
   h. in-service status* |

purposes. [BA, GO, LSE, TO, TSP]
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
# REVISION HISTORY

<table>
<thead>
<tr>
<th>DATE OR VERSION NUMBER</th>
<th>AUTHOR</th>
<th>CHANGE DESCRIPTION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>21JUN18</td>
<td>SPP Engineering Modeling</td>
<td>Updated format</td>
<td></td>
</tr>
<tr>
<td>2018 v1.1</td>
<td>SPP Engineering Modeling</td>
<td>Modified Bus Naming and Map / Model request information</td>
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<td>2018 v1.2</td>
<td>SPP Engineering Modeling</td>
<td>Updated Introduction &amp; Dynamic modeling section</td>
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<td>Updated Station Service section and Shunt Device section</td>
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, data owners, equipment, and data submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1) and the provisions of the

---

1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

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\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.
• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.
• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.
• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.
• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.
• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

**Applicable Data Submitters**

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
**Applicable Equipment**

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT\(^5\). Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned\(^6\) equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT\(^7\).
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT\(^8\).
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT\(^9\), excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT\(^10\).
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.

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5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Sixth Revised Volume No.1, Attachment Al, Part II-1.
8 Sixth Revised Volume No.1, Attachment Al, Part II-2.
9 Sixth Revised Volume No.1, Part III-30.
10 Sixth Revised Volume No.1, Part III-31
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and DataSubmitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes.** In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP. The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models.
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

**Data Transmittal**
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- GlobalScape

2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the "SPP MDWG File Sharing Site", GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP Model Release Guidelines**
**Steady-State and Short Circuit Models**
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables

Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   a. Initialized steady state and regional contingency cases.
      a. Steady-State RAWD case file
      b. Conversion IDEV files

2. Dynamics Cases
   a. Dynamics case input data, output files and instructions including:
      a. Dynamics input data in DYRE format
      b. FLECS code for user defined models
      c. Load conversion CONL file sorted by area
      d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

Compliance

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

1. The Steady-State data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, outages, long name, and associated auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be Non-Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand. DSM consists of controllable and non-controllable systems. Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. Distributed Energy Resources are power resources on the distribution system that
can be aggregated together to provide power to meet Demand. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed agreement, or are in the process of finalizing a signed agreement should be included in the Data Submitter’s load forecast. SPP may reject any MOD projects or PSS® idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Non-coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

On-Peak/Off-Peak Models

Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority coincident peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
</tbody>
</table>

Typically 70% - 80% of Summer On-Peak load level

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.
External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.

**Load Data**
Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID “R1”). These loads should be maintained in the Load Mapping worksheet of the EDST.

**Area Summary Report**
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.
12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

Tie Line Coordination
Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:
1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

Line and Transformer Data
Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.
2. The "from bus," “to bus”, and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to
bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional.

6. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

7. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

8. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.
9. Transformer connection codes\textsuperscript{11} and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

**Bus Data**
For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

**NOTE:** When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

\begin{align*}
1 & - \text{Below 69 kV} & 4 & - \text{138 kV} & 7 & - \text{345 kV} \\
2 & - \text{69 kV} & 5 & - \text{161 kV} & 8 & - \text{500 kV}
\end{align*}

\textsuperscript{11} Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
1. **For generator regulated buses, a desired voltage set point will be given.** Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. **Bus loads should be specified with the real and reactive power values provided as a pair in all entries.** The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

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Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.

**Shunt Data**

Shunt reactive devices are key components used, in conjunction with generating unit excitation, to regulate transmission system voltage, as well as facilitate operating flexibility while assisting to maximize transmission capacity. Shunt reactive devices are typically characterized as either static or dynamic, based upon their responsiveness to system voltage variations.

Static reactive devices tend to respond more slowly, either through automatic or manual switching according to a broader voltage schedule or range of system voltage conditions. Dynamic reactive devices tend to respond very quickly, automatically adjusting their reactive contributions to the...
system so as to maintain a voltage set point (regulating device). The four primary static and dynamic reactive device categories are:

- **Fixed shunt device (Locally-switchable static devices)** - Typically require a switchman to physically close a switch in the field under de-energized conditions. These devices require human interaction at the location of the device in order to change the status and are not self-switching. These devices should be represented as fixed shunt devices in software simulations.

- **Switched Shunt, Locked mode (Remotely-switchable static devices)** – Can be placed in, or taken out of, service by a System Operator remotely operating a switch from a Control Center. These devices require human interaction in order to change the status, are not self-switching, are not used for automatic system adjustments, but are used for manual system adjustments (regulating device). These devices should be represented as switched shunt devices in locked mode (0) in software simulations.

- **Switched Shunt, Discrete mode (Automatically-switchable static devices)** – Can be placed in, or taken out of, service by an automatic controller (e.g., the Protection System) that actuates powered switch closure. These devices are self-switching, are used for automatic system adjustments (regulating device), but not used for manual system adjustments. These devices should be represented as switched shunt devices in a discrete switching mode (1, 3, 4, 5, or 6) in software simulations.

- **Switched Shunt, Continuous mode (Automatically-switchable dynamic devices)** – Reactive contribution is adjusted by an automatic controller. These devices are used for automatic system adjustments (regulating device), but not used for manual system adjustments. Examples of dynamic reactive devices include: static VAR compensators (SVC), static compensators (STATCOM), and direct current voltage source converters (VSC). These devices should be represented as switched shunt devices in a continuous switching mode (2) in software simulations.

Load flow software offers multiple options for modeling shunt reactive devices and care must be used when selecting the appropriate representation. The primary modeling capability considerations for non-rotating mass reactive devices are:

- Shunt implementation: fixed, or switched.
- Simulated control mode: Locked, discrete, or continuous.
- Regulated voltage band limits: high (\(V_{hi}\)) and low (\(V_{lo}\)).

Upon selecting the appropriate modeling representation for the non-rotating mass shunt reactive device, the Data Owners/Submitter shall ensure that the following is entered for:

- **Non-regulating shunt capacitor or reactor device (static, locally-switchable device)**
- **Fixed shunt (no control mode) with a unique shunt ID.**
- **Total reactive device admittance**\(^{12}\) (MW and MVAR) that represents the aggregated contribution of the reactive banks or blocks installed as a fixed device.
- **In-service status**, set to zero (0) if the device is not in-service.

**Regulating shunt devices**

- **Switched shunt** with ‘SW’ shunt ID (forced by software).
- **Total reactive device admittance**\(^{13}\)(MVAR only), differentiated into quantities of admittance that represent the installed controllable device reactive banks or blocks, as appropriate.
- **Regulated voltage band limits**, either as a schedule \((V_{hi} \neq V_{lo})\) for static reactive devices or as a set point \((V_{hi} = V_{lo})\) for dynamic reactive devices, appropriate to the equipment.
- **Reactive limits**, for dynamic reactive devices only.
- **Control mode-of-operation**, as listed above:
  - Static, remotely-switchable device – locked, control mode (0).
  - Static, automatically-switchable device - unlocked, discrete control modes \([1, 3, 4, 5, \text{ or } 6]\).
  - Dynamic device – unlocked, continuous control mode (2).
- **Assignment of the regulated bus**, for switched shunt representations only.
- **In-service status**, set to zero (0) if the device is not in-service.

The Data Owners/Submitter should consider the load flow numerical solution stability implications of the regulated voltage band limits \((V_{hi}, V_{lo})\) when entering data for the shunt reactive devices. The ability of the load flow numerical solver to derive an acceptable voltage state may be impeded by a switched shunt with a discrete control mode whose reactive contribution, when switched, pushes the voltage of its connected bus outside of convergence tolerances. Therefore, a limit difference of less than 0.025 pu shall not be used when entering the regulated voltage band limits \((V_{hi}, V_{lo})\) for a switched shunt reactive device. Similarly, switched shunts shall not be connected to generator buses or to a generator bus through a zero-impedance branch.

All shunt reactive devices attached at transmission-level buses (i.e., 60 kV or greater) or attached to the tertiary of a transmission-level power transformer shall be modeled explicitly and not as loads or aggregated with loads. Further, static reactive devices connected to transmission lines are known as line shunts. The PSS/e load flow software allows line shunts to be modeled as part of the BRANCH data record. An alternative approach is to model the line shunt explicitly by using an intermediate bus and zero-impedance branch (ZBR), as shown in Figure 1, even when the line shunt is locally-switchable only and expected to match the in-service status of the connected branch. In this scenario, losing the transmission line, but not the line shunt, can cause low voltage conditions that may not be realistic.

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12 Shunt conductance and susceptance quantities are entered in units of MW and MVAR representing the total per-unit admittance at rated voltage, on system base MVA.

13 Shunt susceptance quantities (conductance is assumed to be zero) are entered in units of MVAR representing the total per-unit admittance at rated voltage, on system base MVA.
The Data Owner/Submitter must remember that the switched shunt reactive device control mode employed by the load flow software offers significantly more flexibility than shunt reactive devices implemented in the transmission system. Care should be taken to best represent the actual operation of installed shunt reactive devices and not allow unlocked control modes when inappropriate. During the model build process, similar to the process of case conditioning prior to analysis, remotely-switchable devices may be unlocked and automatically-switchable devices may be locked, expressly for the purpose of obtaining a converged load flow solution. However, care must be taken to ensure that the final state of the model contains the correct control mode, including locking, appropriate to the shunt reactive devices represented. The Data Owners/Data Submitters should also consider individual device protection settings as they relate to voltage control mode and limits.

Generator Data
Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per testing requirements in SPP Planning Criteria 7.1.1. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and
PMIN) with auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the sub unsaturated subtransient impedance for those generators modeled by sub-transient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSORCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X”di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.

Modeling of Generator Parameters

1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

Modeling Process for Generator Parameters

a. The Generator parameter P_{MAX} shall be modeled as a gross seasonal maximum capability based on MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

b. Generating plant station service and auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All station service and auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus^{14}, corresponding to the voltage to which the auxiliary load is served. Model representations of auxiliary load connected to the generating unit bus (Figure VII-1), auxiliary load modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

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^{14} Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant auxiliary load.
c. Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

If generating plant station service and auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use “$S_nS$” in the Load ID field for one (Figure VII-4a). If there are more than one aggregated generating plant station service loads (Figure VII-4a) and auxiliary load, use “$S_n$” in the Load ID field to delineate the multiple aggregated loads.

If generating plant station service and auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “$F_n$” in the Load ID field to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “$V_n$” in the Load ID field to designate variable load quantities that do vary with plant dispatch.

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15 “$n$” represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).

Only generating plant station service or auxiliary load IDs should be labeled with “Sn”, “Fn”, or “Vn” all other load types should be labeled differently.

Generating plant station service or auxiliary load IDs of “Sn” or “Vn” should be modeled such that the in-service status of the load follows the in-service status of the generator in which it is connected. For example: Generator 1 is offline, then the associated generating plant station service or auxiliary load with load IDs of “Sn” or “Vn” should also be offline.

d. The Generator Parameters for PMIN, AUX Load, QMAX, and QMIN shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

Modeling of Wind/Solar Renewable Resources $P_{GEN}$

- Spring Light Load Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP coincident Off-Peak hour corresponding to the season of the Light Load case, not to exceed each facility's firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility's long-term firm transmission service amount.
- On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility's firm service amount.
- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build.

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16 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
• When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.
• Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.
• For resources that do not have firm service, $P_{\text{gen}}$ values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

Data Exemption Process
MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the “Exemption Form” and send it via e-mail to “Engineering Modeling” containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.
**Effective date of section 2 is July 1, 2016.
**Effective date of section 4 is July 1, 2016.

Shortfall Guidance Process
A shortfall is defined as an instance of insufficient firm resource to supply firm load. Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.
2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   e. The in-service date shall be based on the expected in-service date of the GI study.
   f. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).
3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of exploratory generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

Remote Generation Modeling

Purpose
This procedure assures that members adhere to a uniform process when modeling remote generation in SPP.

Modeling Process
If a member acquires remote generation outside their Control Area (steady-state model numbered area), the following modeling process should be followed:
   1. All buses should be assigned numbers that are in the host’s control area bus number range.
   2. Area Number/Name should be the host’s control area number.
   3. Zone Number/Name should be in the host’s control area zone range.
   4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
   5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Owner Data and Line Mileage Data (SSAE Control)

To meet the SSAE requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:
   1. Zone Range and Modeling Area Assignments
   2. System Codes
   3. Utilized DC Lines

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.
1. **Area Interchange**
The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
a. The voltage summary,
b. The overloaded branch summary, and
c. The generation summary.

   a. **Voltage Summaries**
Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:
i. QT --- MAX = one-half of MW rating  
ii. QB --- MIN = negative one-third of MW rating  

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).

Generator Owners shall provide all necessary modeling data to the TP and PC, per the requirements of MOD-032-1, prior to the start of any construction. Power flow model topology data shall conform to the requirements in Figure 3 below and transient dynamic models shall conform to the requirements in the section labeled Dynamic Data Format.
Figure 12: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 23: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI, IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.
Data may also be deleted from the models. When a bus is specified for deletion, all associated data for that bus will be removed (e.g., branches, transformers, generators, and loads). **The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified.** Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have “Area interchange control” with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**Steady-State Modeling Requirements**

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.
3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the Xsource value in the steady-state generator data record shall be as follows:
   a. Xsource = X''d for detailed synchronous machine modeling
   b. Xsource = X'd for non-detailed synchronous machine modeling
   c. Xsource = should be equal to locked rotor impedance for an induction machine
   d. Xsource = 1.0 per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E dynamic library models compatible with either representation are available. If a user model representing particular SVC and control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV.

   Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

   If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using R=0.00000 + X=0.0001 and B=0.00000. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled
(generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of $R=0.0001 + X=0.002$ and $B=0.00000$. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – Effective with Revision 28 of PSS®E. To adequately model transformers, the following parameters, at a minimum, are required:
   a. Nominal voltage of windings and bus reference to which the appropriate winding is connected
   b. Impedance(s)
   c. Tap ratios (voltage or phase angle)
   d. Minimum and maximum tap position limits
   e. Number of tap positions (for both the ULTC and NLTC)
   f. Regulated bus (for voltage regulating transformers)
   g. Ratings (normal and emergency)
   h. In-service status
   i. Vector group and Connection code

The measured impedance (resistive and inductive) between each pair of windings shall be specified: data entry options permit these to be entered in (1) per unit on system (100 MVA) base, (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage. Off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding.

8.9 Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

9.10 Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10.11 Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes.

PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The
controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:

a. Real-time operational auto or manual adjustment operation of the PST.

b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.

c. Real-time operational MW flow limits (e.g. ±20 MW).

d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).

e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.

f. Applicable long-term firm transmission service levels for the PST.

11.12. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

12.13. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

13.14. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

14.15. Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

15.16. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16.17. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX
should always be greater than or equal to QMIN. Net maximum and minimum unit output
capabilities should be given unless the generator terminal bus is explicitly modeled, the
generator step up transformer is modeled as a branch, and unit load is modeled at the bus
or buses from which it is supplied.

17.18 Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA),
small capacitors, and small SVCs have limited reactive capability and cannot effectively
regulate transmission bus voltage. Modeling them as regulating increases solution time.
Consideration should be given to modeling them as non-regulating by specifying equal
values for QMIN and QMAX. If several similar machines or devices are located at a bus and
there is a need to regulate with these units, they should be lumped into an equivalent to
speed solution.

18.19 Coordination of Regulating Devices – Multiple regulating devices (generators, switched
shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple
buses connected by Zero Impedance Lines as described above, should have their scheduled
voltage and voltage control ranges coordinated.
Also, regulated bus voltage schedules should be coordinated with the schedules of
adjacent buses. Coordination is inadequate if solving the same model with and
without enforcing machine regulating limits causes offsetting MVAR output changes
greater than 500 MVAR at machines connected no more than two buses away.

19.20 Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per
unit, or below 0.90 per unit should be avoided.

20.21 Flowgates – All transmission elements comprising part of one or more flowgates should be
included in the data submitted by each region. A flowgate is a selected transmission
element or group of elements acting as proxy for the transmission network representing
potential thermal, voltage stability, rotor angle stability, and contractual system constraints
to power transfer.

21. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be
modeled explicitly (not as loads or included with load). The status should be set to zero if
the shunt is not in service. Fixed shunt elements that are directly connected to a bus should
be represented as bus shunts. Fixed shunt elements that are directly connected to and
switch with a branch should be represented as line shunts.

22. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be
modeled explicitly. Continuous mode modeling using a switched shunt should not be used
unless it represents actual equipment (e.g. SVC or induction regulator). The number and
size of switched admittance blocks should represent field conditions. The bandwidth
(difference between VSWHI and VSWLO) of switched shunt devices should be wide enough
that switching one block of admittance does not move the voltage at the bus completely
through the bandwidth, thus causing solution problems at the bus. It is recommended that
the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage.
Switched shunts should not regulate voltage at a generator bus, nor should they be
connected to the network with a zero impedance tie.

23.22 Static Var Systems – Static var elements should be modeled with accurate reactive power
(leading/lagging) limits. An accurate voltage set point and equipment status, as well as any
associated fixed/switched shunt equipment should also be modeled based on actual
seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service
status equal to zero. In-service Static Var Systems should be modeled with an in-service
status equal to one.

24.23 DC Transmission systems – DC transmission systems must be represented with a
sufficiently detailed model to simulate its expected behavior.
25.24. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

25. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it. (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during equivalencing.

4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. Fictitious regulation of buses.

12. Extremely low voltage schedules.

13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under-load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the “From” bus and the second-named bus is taken as the “To” bus. The “From” bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area. While typically analogous to a

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17 The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

18 Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\textsuperscript{19} loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

\textbf{Figure 1. Example of interconnected model areas.}

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\textsuperscript{19} ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (Pgen) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

**Figure 3. Example of Inter-area transfer (transaction).**

Inter-area Bilateral transaction description

Data Owner A exports MW to Data Owner B
Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where remote generation is located to the generation owner control area. If the remote generation is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area's number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

No Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models include full MMWG cases and machine reduced cases. They reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnect resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPP reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the Regional Transmission Organization with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:

1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamics model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code (includes wind farms)
5. ERAG MMWG System Dynamics Database (SDDB)
6. SDDB data update worksheet

The schedule for submission of Dynamic data and list of MDWG Dynamic models (case types) can be found on the SPP corporate website, www.spp.org. SPP MDWG Dynamic Models are published according to the schedule in Section 15 B.

The Dynamics Model is also updated annually with current generator unit information. Steady-State models are used in conjunction with dynamic data to run dynamic simulation.

Dynamics Data Submittal Requirements and Guidelines

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The PSS®E dynamic model types classified as detailed are GENROU, GENSAL, GENROE, GENSAE, and GENDCO.

The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:

a. Detailed data is not available because manufacturer no longer in business.
b. Detailed data is not available because unit is older than 1970.

The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:

a. Unit is a phantom or undesignated unit in a future year MMWG case.
b. Unit is on standby or mothballed and not carrying load in MMWG cases.
The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
   c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
   d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.
   Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.
9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

PROCEDURES FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or –9999.
   c. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      viii. Branches with extreme impedances or tap ratios [BRCH]. Suggested options are:
          a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.

c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.

d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]

c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].

e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)

a. Specify CONEC, CONET, and COMPILE files.

b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.
7. Compile.
9. Restart from the dynamics entry point, this time using “user dynamics”.
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE]
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN].
      Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.
      ii. A tabulation of conditions at each online machine
         a) Terminal voltage
         b) Exciter output voltage
         c) Real and reactive power output
         d) Power factor
         e) Machine angle in degrees
         f) Direct and quadrature axis currents on machine base.
      iii. A diagnosis of initial conditions, either
         a) “Initial conditions check OK”, or
         b) A listing of suspect initial conditions generally states whose time derivative is not “small” (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.
         iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.
   f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.
10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.
11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.
12. Stop simulation. Review output values in tabular and/or graphical form.
13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
   a. Excessive overshoot
b. Sustained oscillations

c. High frequency noise (may be caused by using too long a simulation time step.)

d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((- K) = (-1 / R)\), mechanical power to \((1-1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Dynamic Data Format

PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyr file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

Non-PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

NERC maintains a list of acceptable dynamic models on the NERC website for reference by the GO. Only NERC acceptable dynamic models from the latest approved list shall be provided the applicable TPs and to SPP, as PC, for dynamic model building purposes. The acceptable dynamic model list can be found on the NERC SAMS website ➔ SAMS Reference Materials ➔ NERC Acceptable Model List.

Dynamic models that are considered unacceptable by NERC, shall be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis

2. Dynamic model data is submitted in .dyr format

3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes

4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP

Dynamics Data Validation Requirements
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines
1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).
2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator
Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template
Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.

The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
</tbody>
</table>
Add a new model to an existing unit | No | Yes | A stabilizer is being added to a unit which did not have one.
Delete a model | Bus name, unit ID, model name | No | A stabilizer is removed.
Replace a model with another model of the same equipment group | Bus name, unit ID, model name for deleted model. | Yes for new model. | 1. A DC exciter is replaced by a static exciter. 2. A classical machine model is replaced by a detailed model.
Change bus name and/or unit ID for all models of an existing unit | Old and new names; old and new unit IDs | No |
Change bus number | No | No | Maintain the same name and unit ID and the model data will follow automatically.
Add dynamic models for a new generating unit | Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type | Yes | Same requirements whether unit is at new or existing bus.
Remove a unit and all associated models | Bus name, unit ID | No |

**Complete Set of Dynamics Data**
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

1. The Short Circuit data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specifically for generators, positive, zero, and negative sequence data must also be included. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update. Additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final). The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.
Short Circuit models are developed annually using a subset of the Reliability Steady-State MDWG Powerflow models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company's RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions
SECTION 6: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,
From Area Name,
From Bus #,
From Bus Name,
From Bus kV,
To Region Name,
To Area#,
To Area Name,
To Bus #,
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI (pu),
BI (pu),
GJ (pu),
BJ (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#, 
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#, 
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued

COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RMI1,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#, 
Winding 1 Area Name,
Winding 1 Bus#, 
Winding 1 Bus Name, 
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#, 
Winding 2 Area Name,
Winding 2 Bus#, 
Winding 2 Bus Name, 
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#, 
Winding 3 Area Name,
Winding 3 Bus#, 
Winding 3 Bus Name, 
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBASE2-3,
R3-1,
Three Winding Transformer Data Fields - continued

X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus #(CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RMI1,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued

RMI2,
VMA2,
VMI2,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RMI3,
VMA3,
VMI3,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields

In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (R,I),
DCVMIN,
CCCITMX,
CCCACC,
IPR REGION NAME,
IPR AREA#,
IPR AREA NAME,
IPR Bus#,
IPR BUS NAME,
IPR BUS Kv,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#,
ICR AREA NAME,
ICR BUS#,
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#,
IFR AREA NAME,
IFR BUS#,
IFR BUS NAME,
IFR BUS KV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME, 
ITR BUS KV, 
IDR, 
XCAPR, 
IPI REGION NAME, 
IPI AREA#, 
IPI AREA NAME, 
IPI Bus#, 
IPI BUS NAME, 
IPI BUS Kv, 
NBI, 
GAMMX, 
GAMMN, 
RCI, 
XCI, 
EBASI, 
TRI, 
TAPI, 
TMXI, 
TMNI, 
STPI, 
ICI REGION NAME, 
ICI AREA#, 
ICI AREA NAME, 
ICI BUS#, 
ICI BUS NAME, 
ICI BUS Kv, 
IFI REGION NAME, 
IFI AREA#, 
IFI AREA NAME, 
IFI BUS#, 
IFI BUS NAME, 
IFI BUS Kv, 
ITI REGION NAME, 
ITI AREA#, 
ITI AREA NAME, 
ITI BUS#, 
ITI BUS NAME, 
ITI BUS Kv, 
IDI, 
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
### SECTION 7: APPENDIX II

**UTILIZED IMPEDANCE CORRECTION TABLES**

<table>
<thead>
<tr>
<th>Table Number</th>
<th>Tap or Angle</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60</td>
<td>0.358</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
<td>0.85</td>
</tr>
<tr>
<td>3</td>
<td>180</td>
<td>0.358</td>
</tr>
<tr>
<td>4</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>5</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>6</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>7</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>8</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>9</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>10</td>
<td>121.5</td>
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<tr>
<td>11</td>
<td>121.5</td>
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</tr>
<tr>
<td>12</td>
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<tr>
<td>13</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>14</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>15</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>16</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>17</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>18</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>19</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>20</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>21</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>22</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>23</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>24</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>25</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>26</td>
<td>121.5</td>
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<tr>
<td>27</td>
<td>121.5</td>
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<tr>
<td>28</td>
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<td>0.85</td>
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<tr>
<td>29</td>
<td>121.5</td>
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</tr>
<tr>
<td>30</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>31</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>32</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>33</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>34</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>35</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>36</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>37</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>38</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>39</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>40</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>41</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>42</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>43</td>
<td>121.5</td>
<td>0.85</td>
</tr>
<tr>
<td>44</td>
<td>121.5</td>
<td>0.85</td>
</tr>
</tbody>
</table>
SECTION 8: MOD-032-1 ATTACHMENT 1

MOD-032-1 – ATTACHMENT 1
The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnectionwide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity1 responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios</td>
<td>If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables</td>
<td>Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1.</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>a.</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>b.</td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td>5. Demand [LSE]</td>
<td>3.</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td>6. Wind Turbine Data [GO]</td>
<td>3a.</td>
</tr>
<tr>
<td>3. Generating Units21 [GO, RP (for future planned resources only)]</td>
<td>7. Photovoltaic systems [GO]</td>
<td>3b.</td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
<td>3c.</td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td>9. DC system models [TO]</td>
<td>3d.</td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide data in the same manner as that</td>
<td>10. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
<td>3e.</td>
</tr>
</tbody>
</table>

---

20 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).
21 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.
2 Including synchronous condensers and pumped storage.
<table>
<thead>
<tr>
<th>Required for aggregate Demand under item 2, above.</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
</tr>
<tr>
<td>e. machine MVA base</td>
</tr>
<tr>
<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
</tr>
<tr>
<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
</tr>
<tr>
<td>h. in-service status*</td>
</tr>
<tr>
<td>4. AC Transmission Line or Circuit [TO]</td>
</tr>
<tr>
<td>a. impedance parameters (positive sequence)</td>
</tr>
<tr>
<td>b. susceptance (line charging)</td>
</tr>
<tr>
<td>c. ratings (normal and emergency)*</td>
</tr>
<tr>
<td>d. in-service status*</td>
</tr>
<tr>
<td>5. DC Transmission systems [TO]</td>
</tr>
<tr>
<td>6. Transformer (voltage and phase-shifting) [TO]</td>
</tr>
<tr>
<td>a. nominal voltages of windings</td>
</tr>
<tr>
<td>b. impedance(s)</td>
</tr>
<tr>
<td>c. tap ratios (voltage or phase angle)*</td>
</tr>
<tr>
<td>d. minimum and maximum tap position limits</td>
</tr>
<tr>
<td>e. number of tap positions (for both the ULTC and NLTC)</td>
</tr>
<tr>
<td>f. regulated bus (for voltage regulating transformers)*</td>
</tr>
<tr>
<td>g. ratings (normal and emergency)*</td>
</tr>
<tr>
<td>h. in-service status*</td>
</tr>
</tbody>
</table>
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
MOD-032 Data submission milestones for SPP GIAs.

<table>
<thead>
<tr>
<th>Item</th>
<th>Action</th>
<th>Responsible Party</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Submit Transmission Owner’s Interconnection Facilities and Network Upgrade information to SPP’s MOD-032-1 Model On Demand Database and Engineering Data Submission Tool (EDST).</td>
<td>Transmission Owner</td>
<td>No Later than 120 Calendar Days after the GIA Effective Date</td>
</tr>
<tr>
<td>2</td>
<td>Submit Interconnection Customer’s required power flow, short circuit, and dynamic generating facilities modeling data to SPP’s MOD-032-1 Model On Demand Database and Engineering Data Submission Tool (EDST) pursuant to NERC standard MOD-032-1 and in accordance with SPP MDWG manual requirements.</td>
<td>Interconnection Customer [Note ##]</td>
<td>No Later than 120 Calendar Days after the GIA Effective Date</td>
</tr>
<tr>
<td>3</td>
<td>If data from milestone #1 has changed, Submit Transmission Owner’s Interconnection Facilities and Network Upgrade information to SPP’s MOD-032-1 Model On Demand Database and Engineering Data Submission Tool (EDST) for “as built” facilities.</td>
<td>Transmission Owner</td>
<td>Within 120 Calendar Days before Commercial Operation Date Initial Synchronization Date</td>
</tr>
<tr>
<td>4</td>
<td>If data from milestone #2 has changed, Submit Interconnection Customer’s required power flow, short circuit, and dynamic generating facilities modeling data and Generating Facilities information to SPP’s MOD-032-1 Model On Demand Database and Engineering Data Submission Tool (EDST) for “as built” facilities pursuant to NERC standard MOD-032-1 and in accordance with SPP MDWG manual requirements.</td>
<td>Interconnection Customer [Note ##]</td>
<td>Within 120 Calendar Days before Initial Synchronization Date Commercial Operation Date</td>
</tr>
</tbody>
</table>

Commented [SR1]: OPPD Suggestion

Note ## - If agreed upon by Interconnection Customer and Transmission Owner, the Designating MOD-032-1 Data Submittal Assignment Letter in SPP Model Development Working Group (MDWG) manual Appendix ## can be executed for coordinating data owner and data submitting responsibilities.
Letter of Notice
Designating MOD-032-1 Data Submittal Assignment

On this ______ day of ______________, 20______, _______________________ and ________________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following:

On _______________, 20____, ______________________, Data Owner, and ________________________, Data Submitter, entered into an agreement through which ________________________ has agreed to submit on behalf of ________________________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

___________________________________________________________________________________________
___________________________________________________________________________________________
___________________________________________________________________________________________

The accuracy of the data is the responsibility of the data owner. This notice does not shift the compliance obligation from the data owner to the data submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER:

By: ______________________________

Printed Name: _____________________

Title: _____________________________

Date: _________________

SPP hereby acknowledges receipt of this notice.

By: ______________________________

Printed Name: _____________________

Title: _____________________________

Date: _________________

On behalf of DATA SUBMITTER:

By: ______________________________

Printed Name: _____________________

Title: _____________________________

Date: _________________
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<td><strong>2020 MDWG Schedule FINAL</strong></td>
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<td><strong>2020 MDWG Model Series (Powerflow &amp; Short Circuit) - PSS/E v34.5.1 - MOD v10 (MOD-032 East)</strong></td>
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**Pass 0: Powerflow (PF) & Short Circuit (SC) Data (Topology, Sequence Data & Initial Generator Retirements Updates)**
- SPP Staff send out kick-off email
- **Trial 1: SPP Staff Lock Down MOD and EDST**
- SPP Staff compile EDST data and Review/Build Pass 0 - Trial 1 Solved Powerflow models

**SPP Staff Post Pass 0 - Trial 1 models, DocuCode, and MOD-033-1 unacceptable differences for Data Submitter Review**
- SPP Staff Request Generator Facility Data for recently Executed GIAs
- Data Submitters review Pass 0 - Trial 1 models and provide PF and SC data Updates through MOD and EDST

**Data Submitter Updates (Topology, Sequence Data & Generator Retirements) Due**
- **Trial 2: SPP Staff Lock Down MOD and EDST**
- SPP Staff compile EDST data and Review/Build Pass 0 - Trial 2 Solved Powerflow models

**SPP Staff Post Pass 0 - Trial 2 models, DocuCode, and conflicting generator retirement list for Data Submitter Review**
- Pass 0 - Complete

**Pass 1 - Coordinate & Submit Load, Generation, Transaction, Topology and SC Data Updates**
- Data Submitters review Pass 0 - Trial 2 models and submit load, generation, transaction, topology and SC data updates through MOD and EDST for use in Pass 1 - Trial 1 Models

**Data Submitter Updates (Load, Generation, Transaction, Topology & Sequence Data) Due**
- **Trial 1: SPP Staff Lock Down MOD and EDST**
- SPP Staff compile EDST data and Review/Build Pass 1 - Trial 1 Solved Powerflow models

**SPP Staff Post Pass 1 - Trial 1 PF and SC models and DocuCode for Data Submitter Review**
- Data Submitters review Pass 1 - Trial 1 models and submit PF and SC data updates through MOD and EDST for use in Pass 1 - Trial 2 Models

**Data Submitter Updates (Load, Generation, Transaction, Topology & Sequence Data) Due**
- **Trial 2: SPP Staff Lock Down MOD and EDST**
- SPP Staff compile EDST data and Review/Build Pass 1 - Trial 2 Solved Powerflow models

**SPP Staff Post Pass 1 - Trial 2 PF and SC models and DocuCode for Data Submitter Review**
- SPP Staff incorporate 2019 AG1 Transmission Service updates into EDST

**SPP Staff Review/Build Pass 1 - Trial 2 Short Circuit Models**
- *Pass 1 - Complete*

**Pass 2 (Last Chance for Generator Additions & Retirements, Loads and Interchange)**
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<tr>
<th>MDWG Face-to-Face Meeting</th>
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<tr>
<td>Data Submitters review Pass 1 - Trial 2 models and submit PF and SC data updates through MOD and EDST for use in Pass 2 Models</td>
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<tr>
<td>Last Chance - Data Submitters provide final Transmission Service Inputs (AG1) Data, review Pass 2 models/data submission through MOD, update load and generation reports/reconcile transaction discrepancies</td>
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<tr>
<td>SPP Staff Lock Down MOD and EDST</td>
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<tr>
<td>SPP Staff compile EDST data and Review/Build Pass 2 Solved Powerflow models (Merge with latest MMWG models)</td>
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<td><strong>SPP Staff Review/Build Pass 2 Short Circuit Models (Merge with latest SERC SC Models)</strong></td>
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<td><strong>SPP Staff Post Pass 2 PF and SC models and DocuCode for Data Submitter Review</strong></td>
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<td><strong>FINAL PASS (Final Generation Dispatch, DocuCheck Issues and Topology Updates)</strong></td>
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<td>Data Submitters Review Pass 2 models and submit PF and SC corrections only through MOD and EDST for use in the Final Pass models</td>
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<td>Data Submitters - Final Submission for generation dispatch, docucheck corrections and topology data updates through MOD and EDST</td>
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<td>SPP Staff compile EDST data and Review/Build Final Pass Solved Powerflow models</td>
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<td>Convert models from PSSE v34 to v33</td>
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<td><strong>SPP Staff Review/Build Final Pass Short Circuit Models</strong></td>
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<td><strong>SPP Staff Post Final Pass PF and SC Models for MDWG Approval</strong></td>
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<td><strong>MDWG Review 2020 Series MDWG Powerflow and Short Circuit Models for Finalization</strong></td>
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<td>Finalization - Call to Vote and Approve 2020 MDWG Powerflow and Short Circuit Models</td>
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**Key:**
- Summary Tasks - gray fill
- SPP Staff Lock Down MOD and EDST in orange bold
- Data Submitters Review in green bold
- Data Submitters Updates Due in red bold
- SPP PF Build Tasks in bold
- SPP SC Build Tasks in blue bold
- SPP Posting or Pass Complete in bold italic
- MDWG Face-to-Face Meeting in purple bold
- Final SPP Staff Member Conference Call Vote and Approval in dark green bold italic
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2020 MDWG
2021 ITP Model Selection

MDWG
May 20, 2018
Overview and Recommendations

• PSSE Version
  • SPP & MDWG Power Flow Focus Group recommends using PSSE v34.5.1
    • Convert to v34.6 for ACCC parallel processing feature fixed

• MOD Version
  • SPP recommends moving to MOD v10
    • Compatible with PSSE v34
    • Node breaker capability
    • Several bug fixes and enhancements

• Schedule and Models
  • SPP recommends approving the schedule and model selection included in the background material
2020 MDWG / 2021 ITP Schedules

- 2020 MDWG Model Series (Powerflow & Short Circuit) - PSS/E 34.6 - MOD 10 (MOD-032)
- 2021 ITP Model Series (Powerflow & Short Circuit)
- 2021 ITP Scope Development
- Load and Generation Review
- Resource Planning
- Siting and Generator Outlet Facilities
- 2021 ITP Market Economic Model Build
- Finalize 2021 ITP Powerflow & Short Circuit Models (Updates from 2020 ITP)
- Constraint Assessment
- 2021 ITP Market Powerflow Models
- Needs Assessment (Economic/Policy/Reliability/Operational)
- Solutions Development and Evaluation
- Portfolio Development
- Benefit Metrics
- Sensitivity Analysis
- Stability Analysis
- Rate Impacts
- Final Report
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<td>2031</td>
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## Proposed (DRAFT) Simplified SPP MOD Project Type/Status Matrix

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Must be committed to this Model Set</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP-approved Transmission System Upgrade</td>
<td>Must be SPP Board-approved for ATRR inclusion as part of the SPP Transmission System or have an NTC for: 1) transmission service request(s); 2) transmission changes associated with Attachment AQ project(s), including changes to normally-open/closed topology; 3) transmission changes associated with Generation Interconnection Service project(s); 4) transmission changes originating from the Integrated Transmission Planning (ITP) process; 5) transmission changes originating from the Balanced Portfolio process; 6) transmission changes directed by the high-priority study process; 7) transmission changes associated with Sponsored Upgrades.</td>
<td>MDWG</td>
<td>ITP</td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
<td>An expected change to the SPP Transmission System that does not yet have or does not require an NTC, including: 1) transmission changes budgeted for or planned by the TO; 2) transmission changes budgeted for by a Transmission Customer or other entity; 3) transmission changes resulting from an emergency (e.g., unplanned equipment failure); 4) transmission, load, or generation changes that otherwise have a strong likelihood or commitment to implement (e.g., load changes not yet approved by Attachment AQ, a GI with an IA but on suspension, a GI without an IA, etc.)</td>
<td>MDWG</td>
<td>ITP</td>
</tr>
<tr>
<td>Attachment AQ Load Change</td>
<td>Changes to load and/or delivery points approved in accordance with Attachment AQ.</td>
<td>MDWG</td>
<td>ITP</td>
</tr>
<tr>
<td>Generation Interconnection</td>
<td>Additions or changes to generating units approved in accordance with the Large or Small Generator Interconnection Procedure (LGIP, SGIP) that: 1) have an executed Interconnection Agreement (IA), and 2) are not suspended.</td>
<td>MDWG</td>
<td>ITP</td>
</tr>
<tr>
<td>Network Outage</td>
<td>Changes to the existing SPP Transmission System network topological status only (both placed out-of-service or returned to service).</td>
<td>MDWG</td>
<td>ITP</td>
</tr>
<tr>
<td>Modeling Correction</td>
<td>Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD network data.</td>
<td>MDWG</td>
<td>ITP</td>
</tr>
<tr>
<td>Corrections for System Intact Criteria</td>
<td>Changes to the transmission model necessary to correct basecase system intact voltage or thermal criteria violations only.</td>
<td>MDWG</td>
<td>ITP</td>
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# SPP MOD Project Type/Status Matrix

<table>
<thead>
<tr>
<th>Type</th>
<th>Status</th>
<th>Description</th>
<th>Model Set</th>
<th>Special Study</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>GI w/ IA</td>
<td>Projects identified through the SPP Generator Interconnection Procedure (GIP) with an executed Generator Interconnection Agreement (GIA) or executed Interim Generator Interconnection Agreement (IGIA) and not on suspension.</td>
<td>X X X X X</td>
<td>This also includes projects associated with an interconnecting generator that have been issued an NTC by SPP and may not have been included in an Interconnection Agreement. MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTCPID/UID number. Example Prj/Idv Name:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachment AQ</td>
<td>Changes to delivery points affecting load sinks, changes to system configuration (including normally-open/closed topology), and transmission upgrades identified as part of adding delivery points to the SPP system in accordance with Attachment AQ to the SPP Tariff. Any Notification to Construct (NTC) associated with attachment AQ must use this status</td>
<td>X X X X X</td>
<td>MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, DPA/DPNS number. Example Prj/Idv Name:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Priority</td>
<td>Transmission upgrades recommended by SPP through a stakeholder requested or internally initiated high priority study or Balanced Portfolio evaluation which provide economic benefit to SPP stakeholders and have an NTC from SPP which has been accepted by the Transmission Owner.</td>
<td>X X X X X</td>
<td>SPP projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTCPID/UID number. Example Prj/Idv Name:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ITP</td>
<td>Transmission upgrades determined through the ITP study process that have an NTC from SPP and have been accepted by the Transmission Owner (TO).</td>
<td>X X X X X</td>
<td>MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, DPA/DPNS number. Example Prj/Idv Name:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned Change</td>
<td>Planned Transmission Upgrades that have been reviewed and approved by SPP but do not require NTCs. These types of upgrades are typically considered non-material modifications to the SPP system</td>
<td>X X X X X</td>
<td>SPP should be notified of these Planned system changes through the Request Management System (RMS) for review before submitting to MOD.</td>
<td></td>
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<tr>
<td>Sponsored Upgrade</td>
<td>Transmission upgrades requested by any entity and evaluated by SPP, which have an NTC or executed contract financially committing the Project Sponsor to the upgrade.</td>
<td>X X X X X</td>
<td>MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTCPID/UID number. Example Prj/Idv Name:</td>
<td></td>
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<tr>
<td>TS</td>
<td>Service Upgrades identified through an Aggregate Transmission Service Study with an executed Transmission Service Agreement, and an NTC from SPP which has been accepted by the Transmission Owner.</td>
<td>X X X X X</td>
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<tr>
<td>Network</td>
<td>Projects that change network topology status. Constructed facilities that are out-of-service or normally open.</td>
<td>X X X X X</td>
<td></td>
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<tr>
<td>Outage</td>
<td>Projects that update existing MOD network data and will be immediately committed to the MOD base case upon review. This also includes existing facilities approved for inclusion as part of the SPP Transmission System through SPP's Attachment AI process</td>
<td>X X X X X</td>
<td>The MOD Network Type is reserved for projects that are built as of the current day, i.e. the MOD base case. The Correction status is for corrections to existing MOD base case, or network data.</td>
<td></td>
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<tr>
<td>Correction</td>
<td></td>
<td>X X X X X</td>
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**Model Set**
- MDWG
- ITP
- TS
- GI

**Notes**
- Example Prj/Idv Name: 
  - a. Project name: 525_WFEC_Midwest-Franklin_Rebuild_NTC2002 OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_DPNS-20###-Month-###.prj
  - b. PROFILE name: 659_BEPC_2017MDWGP4-18S.raw or Nextera_2017MDWGP4-18S.raw
<table>
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<tr>
<th>SPP Unapproved</th>
<th>Base Case Fix</th>
<th>Transmission model modifications necessary to ensure that only basecase system intact MMWG violations are corrected</th>
<th>X</th>
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</thead>
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<tr>
<td>Future Change</td>
<td>An expectation can be defined by any of: a project budgeted for or planned by the Transmission Owner (TO), a project budgeted by a Transmission Customer (TC) or other entity, projects currently under study at SPP but unapproved, or any project that otherwise has a strong likelihood or commitment to implement. This includes GI’s with an GIA but on suspension, or GI without an GIA or IGIA.</td>
<td></td>
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</tbody>
</table>

**Definitions**

- **MOD**: Model On Demand
- **TS**: Transmission Service
- **GI**: Generation Interconnection
- **NTC**: Notification to Construct - A written notice from the Transmission Provider directing an entity that has been selected to construct one or more transmission project(s) to begin or continue implementation of the transmission project(s) in accordance with the project's requirements.
- **NERC**: North American Electric Reliability Council
- **SPP**: Southwest Power Pool
- **ITP**: Integrated Transmission Planning
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP-approved Transmission System Upgrade</td>
<td>Must have an NTC for: 1) transmission service requests; 2) transmission changes originating from the integrated transmission planning (ITP) process; 3) transmission changes originating from the Balanced Portfolio process; 4) transmission changes directed by the high priority study process; 5) transmission changes associated with sponsored upgrades.</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Transmission changes that materially-modify the SPP Transmission System. Material changes that materially-modify the SPP Transmission System are submitted separately under the &quot;Generation Interconnection&quot; or &quot;Attachment AQ Load&quot; MOD Types.</td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
<td>An expected change to the SPP Transmission System that does not yet have or does not require an NTC, including: 1) transmission changes budgeted for or planned by the TO; 2) transmission changes budgeted for by a Transmission Customer or other entity; 3) transmission changes originating from the balanced portfolio process; 4) transmission, civil, or generation changes that otherwise have a strong likelihood or commitment to implement (e.g., load changes not yet approved by Attachment AG, a GI with an IA but on suspension, a GI without an IA, etc.)</td>
<td>Acknowledged</td>
<td>X X X X X</td>
<td>For material changes, Data Submitters will receive an acknowledgment as a way of notifying SPP.</td>
</tr>
<tr>
<td>Attachment AG</td>
<td>Changes to load and/or delivery points approved in accordance with Attachment AG, including any transmission changes associated with the Attachment AG project (e.g., equipment upgrades, changes to normally-opened/closed topology).</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Material transmission changes, including upgrades and changes to normally-opened/closed topology, associated with the approved Attachment AG project.</td>
</tr>
<tr>
<td>Generation Interconnection</td>
<td>Additions or changes to generating units, including any transmission changes associated with the Generation Interconnection Service project, approved in accordance with the Generator Interconnection Procedure (GIP) that: 1) have an executed Interconnection Agreement (AG) or executed interim Generator Interconnection Agreement (IGA), and 2) are not suspended.</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Material transmission changes, including upgrades and changes to normally-opened/closed topology, associated with the approved Attachment AG project.</td>
</tr>
<tr>
<td>Network Status</td>
<td>Changes to the existing SPP Transmission System network topological status only if both placed out-of-service or returned to service.</td>
<td>Update</td>
<td>X X X X X</td>
<td>Projects with this status will not be indicated in the RMS as being taken out of service.</td>
</tr>
<tr>
<td>Modeling Correction</td>
<td>Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD network data.</td>
<td>Update</td>
<td>X X X X X</td>
<td>Projects with this status will not be indicated in the RMS as being taken out of service.</td>
</tr>
<tr>
<td>System Intact Alteration</td>
<td>Changes to the transmission model necessary to correct basecase system intact voltage (e.g., to conform to RB500 voltage control, thermal criteria violations, or other basecase condition modifications (e.g., addition of an exploratory generating unit which provided resource for shortfall).</td>
<td>Update</td>
<td>X</td>
<td>Projects with this status will not be indicated in the RMS as being taken out of service.</td>
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</table>
## SPP MOD Project Type/Status Matrix

<table>
<thead>
<tr>
<th>Type</th>
<th>Status</th>
<th>Description</th>
<th>MDWG</th>
<th>ITP</th>
<th>TS</th>
<th>GI</th>
<th>Special Study</th>
<th>Notes</th>
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<tr>
<td></td>
<td>w/ NTC (Approved)</td>
<td>Transmission upgrades identified through an Aggregate Transmission Service Study with an executed Transmission Service Agreement and a Notification To Construct from SPP which has been accepted by the Transmission Owner.</td>
<td>X</td>
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<tr>
<td></td>
<td>Proposed (No NTC)</td>
<td>Proposed transmission upgrades identified through a Aggregate Transmission Service Study that have not been issued a Notification To Construct by SPP.</td>
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<td></td>
<td>w/ IA</td>
<td>Projects identified through the Large or Small Generator Interconnection Procedure (LGIP, SGIP) with an executed Interconnection Agreement and not on suspension.</td>
<td>X</td>
<td>X</td>
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<td></td>
<td>w/ IA on Suspension</td>
<td>Projects identified through the Large or Small Generator Interconnection Procedure (LGIP, SGIP) with an executed Interconnection Agreement and on suspension.</td>
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<td>X</td>
<td>Due to the nature of the GI cluster studies, projects associated with an interconnecting generator that has gone on suspension but are also part of an interconnecting generator or generators actively moving forward will be included as needed with data for those interconnecting generators not on suspension.</td>
</tr>
<tr>
<td></td>
<td>No IA</td>
<td>Projects identified through the Large or Small Generator Interconnection Procedure without an executed Interconnection Agreement.</td>
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<tr>
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<td>w/ NTC</td>
<td>STEP Appendix B transmission upgrades determined through the ITP study process that have a Notification to Construct from SPP which has been accepted by the Transmission Owner.</td>
<td>X</td>
<td>X</td>
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<tr>
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<td>w/ NTC-C</td>
<td>STEP Appendix B transmission upgrades determined through the ITP study process that have a Conditional Notification to Construct from SPP which has been accepted by the Transmission Owner.</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>w/ NTC (Under Review)</td>
<td>STEP Appendix B transmission upgrades determined through the ITP study process that have a Notification to Construct from SPP and have been requested by the Transmission Owner to be re-evaluated.</td>
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<tr>
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<td>w/ ATP</td>
<td>STEP Appendix A transmission upgrades determined through the ITP study process that have an Authorization to Plan from SPP which has been accepted by the Transmission Owner.</td>
<td>?</td>
<td>?</td>
<td>?</td>
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<td>?</td>
<td>(ATP inclusion in models is still under discussion)</td>
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<tr>
<td></td>
<td>STEP (w/NTC)</td>
<td>Appendix B Projects that have a Notification to Construct or Transmission Owner Planning Criteria with an issued Notification To Construct.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>The STEP (w/NTC) status refers to projects that previously received an NTC via the annual SPP reliability assessment prior to implementation of the ITP process. It should not be used for new project submissions.</td>
</tr>
<tr>
<td></td>
<td>TO Planned</td>
<td>Planned projects that have been budgeted by an individual Transmission Owning company with firm commitment to build.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>The default MOD Project Type for projects that are to be built in the future but are not apart of any SPP planning processes under Attachment O to the Tariff is Reliability. For projects that are speculative, but needed to meet compliance issues, the default status is NERC Standard Compliance (Transmission) and would be modeled in the MDWG and as needed in Special Study model sets. For projects that are approved and budgeted, which need to go in all models, the default status is TO Planned.</td>
</tr>
<tr>
<td></td>
<td>NERC Standard Compliance (Transmission)</td>
<td>Transmission upgrades needed to comply with NERC Reliability Standards, SPP Criteria, or individual Transmission Owner planning criteria that have not been identified in the STEP.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>NERC Standard Compliance (Generation)</td>
<td>Generation projects needed to comply with NERC Reliability Standards, SPP Criteria, individual Transmission Owner planning criteria that have not been identified in the STEP.</td>
<td>X</td>
<td></td>
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<tr>
<td></td>
<td>Stakeholder Driven (Budgeted)</td>
<td>Transmission upgrades, requested by a Transmission Customer or other entity, which are budgeted and are moving forward.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>Requested Category</td>
<td>Description</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Stakeholder Driven (Proposed)</td>
<td>Transmission upgrades, requested by a Transmission Customer or other entity, which do not meet the definition of any other category of Network Upgrades.</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Attachment AQ</td>
<td>Transmission upgrades identified under Attachment AQ to the SPP Tariff.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>High Priority</td>
<td>Transmission upgrades recommended by SPP through a stakeholder requested or internally initiated high priority study or Balanced Portfolio evaluation which provide economic benefit to SPP stakeholders and have a Notification to Construct from SPP which has been accepted by the Transmission Owner.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sponsored Upgrade</td>
<td>Transmission upgrades requested by any entity and evaluated by SPP, which have a an executed contract financially committing the Project Sponsor to the upgrade.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
<td>Alternative</td>
<td>Transmission upgrades that are alternatives to any STEP or other project that will be kept in the MOD database for possible inclusion in a future model set.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Network</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Energized</td>
<td>Transmission upgrades that are in-service from a previous MOD Type &amp; Status. Constructed facilities that are in-service.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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</tr>
<tr>
<td>Outage</td>
<td>Projects that change network topology status. Constructed facilities that are out-of-service or normally open.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td></td>
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<tr>
<td>Correction</td>
<td>Projects that update existing MOD network data and will be immediately committed to the MOD base case upon review.</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Definitions**

- **MOD**: Model On Demand
- **TS**: Transmission Service
- **GI**: Generation Interconnection
- **NTC**: Notification to Construct
- **Network**: MOD "base case" data intended to be equivalent to a current season, as built, SPP transmission system.
- **NERC**: North American Electric Reliability Council
- **SPP**: Southwest Power Pool
- **ITP**: Integrated Transmission Planning
- **ATP**: Authorization to Plan
- **STEP**: SPP Transmission Expansion Plan as defined in Attachment O to the SPP Tariff
MODEL DEVELOPMENT
PROCEDURE MANUAL
Model Development Working Group

Applicable to the 2020 Series MDWG Model Build

Published on February-June XX, 2019

MODEL DEVELOPMENT WORKING GROUP
# Revision History

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<tr>
<th>Date or Version Number</th>
<th>Author</th>
<th>Change Description</th>
<th>Comments</th>
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<td>21Jun18</td>
<td>SPP Engineering Modeling</td>
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<td>SPP Engineering Modeling</td>
<td>Modified Bus Naming and Map / Model request information</td>
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<td>2018 v1.2</td>
<td>SPP Engineering Modeling</td>
<td>Updated Introduction &amp; Dynamic modeling section</td>
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<td>2018 v2.0</td>
<td>SPP Engineering Modeling</td>
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<td>2019 v2.3</td>
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<td>Updated Station Service section and Shunt Device section</td>
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<td>2019 v2.4</td>
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the
development of Near-term and Long-term Transmission Planning Horizon models necessary to
support analysis of the capability, reliability, and suitability of the SPP Transmission System. This
section describes the applicability of entities, data owners, equipment, and data submitters to
which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s
planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each
of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org.
Additionally, the schedule for submission of data and the list of MDWG models (case
types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for
model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases)
that include a reasonable projection of the anticipated transmission system conditions as will be
operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability
Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission
Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability
planning and compliance assessments. In addition, the base cases are developed in support of
various SPP planning processes in accordance with SPP model data and reporting procedures that
include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic
disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC
by applicable Data Submitters, meant to represent the transmission system in the SPP region in a
steady-state, system-intact condition. The system topology, generator dispatch, and system loads
modeled in the base cases are intended to be respective and representative of the projected
transmission system as will be operated within the SPP footprint under reasonably anticipated
weather and time-of-day conditions for the year and season being represented in each base case.
Reasonable projections within each case include all firm generator commitments, forecasted load
commitments, firm interchange commitments, expected transmission topology and expected
seasonal transmission or generation outages. Additionally, base cases may include reasonable
system projections based on details specified in later sections of this document and based on
historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon
accurate and comprehensive data collection, review, and compilation. The SPP Model Development
Working Group recognizes that to properly develop SPP Transmission System models, a constituency
of responsible entities must collaborate in the model building effort. The transmission system
subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP
Transmission System models. Therefore, consistent with both the applicability of the NERC Data for
Power System Modeling and Analysis Reliability Standard (MOD-032-1) LAND the provisions of the

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1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶
61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

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2 Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

3 For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner.4 When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT\textsuperscript{5}. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned\textsuperscript{6} equipment for which non-equivalenced\textsuperscript{7} modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT\textsuperscript{8}.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT\textsuperscript{9}.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT\textsuperscript{10}, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT\textsuperscript{11}.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise,

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5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Equivalencing is a general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.
8 Sixth Revised Volume No.1, Attachment AI, Part II-1.
9 Sixth Revised Volume No.1, Attachment AI, Part II-2.
10 Sixth Revised Volume No.1, Part III-30.
11 Sixth Revised Volume No.1, Part III-31
consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted. Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of data.** An early and complete submission of a Data Owner's modeling data does not eliminate the need for the Data Owner to participate in all model-building passes. In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner's model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.
The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models.
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

**Data Transmittal**
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- [GlobalScape](#)

2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the “SPP MDWG File Sharing Site”, [GlobalScape](#).
Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP Model Release Guidelines**
**Steady-State and Short Circuit Models**

SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables
Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   Initialized steady state and regional contingency cases.
   a. Steady-State RAWD case file
   b. Conversion IDEV files

2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP's website, spp.org, under the documents section of the Model Development Working Group.

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

Compliance

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

1. The Steady-State data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, outages, long name, and associated auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts that meet TPL-001 requirements with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand. DSM consists of controllable and non-controllable systems. Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. Distributed Energy Resources are power resources on the distribution system that can be aggregated together to provide power to meet Demand. For purposes of transmission
planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models. When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have a signed updated service agreement, or are in the process of finalizing a signed service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS®E idevS that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Not coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

On-Peak/Off-Peak Models
Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority coincident peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td></td>
<td>Typically 70% - 80% of Summer On-Peak load level</td>
</tr>
</tbody>
</table>

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.
External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.

**Load Data**

Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID “R1”). These loads should be maintained in the Load Mapping worksheet of the EDST.

**Area Summary Report**

The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.
12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**
Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed.
This coordination should consist of:
1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**
Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The "from bus," “to bus”, and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to
bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional.

6. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

7. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

8. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.
9. Transformer connection codes\textsuperscript{12} and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

**NOTE:** When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

\[
\begin{align*}
1 & - \text{Below 69 kV} & 4 & - \text{138 kV} & 7 & - \text{345 kV} \\
2 & - \text{69 kV} & 5 & - \text{161 kV} & 8 & - \text{500 kV}
\end{align*}
\]

\textsuperscript{12} Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
1. **For generator regulated buses, a desired voltage set point will be given.** Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. **Bus loads should be specified with the real and reactive power values provided as a pair in all entries.** The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

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Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.

**Shunt Data**

Shunt reactive devices are key components used, in conjunction with generating unit excitation, to regulate transmission system voltage, as well as facilitate operating flexibility while assisting to maximize transmission capacity. Shunt reactive devices are typically characterized as either static or dynamic, based upon their responsiveness to system voltage variations.

Static reactive devices tend to respond more slowly, either through automatic or manual switching according to a broader voltage schedule or range of system voltage conditions. Dynamic reactive devices tend to respond very quickly, automatically adjusting their reactive contributions to the
system so as to maintain a voltage set point (regulating device). The four primary static and dynamic reactive device categories are:

- **Fixed shunt device (Locally-switchable static devices)** - Typically require a switchman to physically close a switch in the field under de-energized conditions. These devices require human interaction at the location of the device in order to change the status and are not self-switching. These devices should be represented as fixed shunt devices in software simulations.

- **Switched Shunt, Locked mode (Remotely-switchable static devices)** – Can be placed in, or taken out of, service by a System Operator remotely operating a switch from a Control Center. These devices require human interaction in order to change the status, are not self-switching, are not used for automatic system adjustments, but are used for manual system adjustments (regulating device). These devices should be represented as switched shunt devices in locked mode (0) in software simulations.

- **Switched Shunt, Discrete mode (Automatically-switchable static devices)** – Can be placed in, or taken out of, service by an automatic controller (e.g., the Protection System) that actuate powered switch closure. These devices are self-switching, are used for automatic system adjustments (regulating device), but not used for manual system adjustments. These devices should be represented as switched shunt devices in a discrete switching mode (1, 3, 4, 5, or 6) in software simulations.

- **Switched Shunt, Continuous mode (Automatically-switchable dynamic devices)** – Reactive contribution is adjusted by an automatic controller. These devices are used for automatic system adjustments (regulating device), but not used for manual system adjustments. Examples of dynamic reactive devices include: static VAR compensators (SVC), static compensators (STATCOM), and direct current voltage source converters (VSC). These devices should be represented as switched shunt devices in a continuous switching mode (2) in software simulations.

Load flow software offers multiple options for modeling shunt reactive devices and care must be used when selecting the appropriate representation. The primary modeling capability considerations for non-rotating mass reactive devices are:

- Shunt implementation: fixed, or switched.
- Simulated control mode: Locked, discrete, or continuous.
- Regulated voltage band limits: high \((V_{hi})\) and low \((V_{lo})\).

Upon selecting the appropriate modeling representation for the non-rotating mass shunt reactive device, the Data Owners/Submitter shall ensure that the following is entered for:

- **Non-regulating shunt capacitor or reactor device (static, locally-switchable device)**

- Fixed shunt (no control mode) with a unique shunt ID.
• Total reactive device admittance\textsuperscript{13} (MW and MVAR) that represents the aggregated contribution of the reactive banks or blocks installed as a fixed device.
• In-service status, set to zero (0) if the device is not in-service.

\textit{Regulating shunt devices}

• Switched shunt with ‘SW’ shunt ID (forced by software).
• Total reactive device admittance\textsuperscript{14} (MVAR only), differentiated into quantities of admittance that represent the installed controllable device reactive banks or blocks, as appropriate.
• Regulated voltage band limits, either as a schedule \((V_{hi} \neq V_{lo})\) for static reactive devices or as a set point \((V_{hi} = V_{lo})\) for dynamic reactive devices, appropriate to the equipment.
• Reactive limits, for dynamic reactive devices only.
• Control mode-of-operation, as listed above:
  o Static, remotely-switchable device – locked, control mode (0).
  o Static, automatically-switchable device - unlocked, discrete control modes (1, 3, 4, 5, or 6).
  o Dynamic device – unlocked, continuous control mode (2).
• Assignment of the regulated bus, for switched shunt representations only.
• In-service status, set to zero (0) if the device is not in-service.

The Data Owners/Submitter should consider the load flow numerical solution stability implications of the regulated voltage band limits \((V_{hi}, V_{lo})\) when entering data for the shunt reactive devices. The ability of the load flow numerical solver to derive an acceptable voltage state may be impeded by a switched shunt with a discrete control mode whose reactive contribution, when switched, pushes the voltage of its connected bus outside of convergence tolerances. Therefore, a limit difference of less than 0.025 pu shall not be used when entering the regulated voltage band limits \((V_{hi}, V_{lo})\) for a switched shunt reactive device. Similarly, switched shunts shall not be connected to generator buses or to a generator bus through a zero-impedance branch.

All shunt reactive devices attached at transmission-level buses (i.e., 60 kV or greater) or attached to the tertiary of a transmission-level power transformer shall be modeled explicitly and not as loads or aggregated with loads. Further, static reactive devices connected to transmission lines are known as line shunts. The PSS/e load flow software allows line shunts to be modeled as part of the BRANCH data record. An alternative approach is to model the line shunt explicitly by using an intermediate bus and zero-impedance branch (ZBR), as shown in Figure 1, even when the line shunt is locally-switchable only and expected to match the in-service status of the connected branch. In this scenario, losing the transmission line, but not the line shunt, can cause low voltage conditions that may not be realistic.

\textsuperscript{13} Shunt conductance and susceptance quantities are entered in units of MW and MVAR representing the total per-unit admittance at rated voltage, on system base MVA.

\textsuperscript{14} Shunt susceptance quantities (conductance is assumed to be zero) are entered in units of MVAR representing the total per-unit admittance at rated voltage, on system base MVA.
The Data Owner/Submitter must remember that the switched shunt reactive device control mode employed by the load flow software offers significantly more flexibility than shunt reactive devices implemented in the transmission system. Care should be taken to best represent the actual operation of installed shunt reactive devices and not allow unlocked control modes when inappropriate. During the model build process, similar to the process of case conditioning prior to analysis, remotely-switchable devices may be unlocked and automatically-switchable devices may be locked, expressly for the purpose of obtaining a converged load flow solution. However, care must be taken to ensure that the final state of the model contains the correct control mode, including locking, appropriate to the shunt reactive devices represented. The Data Owners/Data Submitters should also consider individual device protection settings as they relate to voltage control mode and limits.
Generator Data

Check Generator output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per capability testing requirements in SPP Planning Criteria 7.1.1 and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator. Generator real power rated capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with appropriate auxiliary load modeled explicitly. Generator reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit testing at real power capabilities and set appropriate to the modeled MW dispatch amount (PGEN). Energy storage (e.g., pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (PGENgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour.

Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The DataModel Owner/Submitter shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to ZSOURCE Table:

For dynamic simulation, this complex impedance must be set equal to the subtransient impedance for those generators modeled by sub-transient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X"di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

For generating units with small X/R ratios (such as small, renewable units) the armature resistance (Ra) must be included in the generator model and, therefore, a resistive component of ZSOURCE may not be zero-valued must be greater than zero. However, if a synchronous unit has a sufficiently large X/R ratio, the value of ZR may be neglected, leading to the observations that:
- Synchronous impedance (Zd) is equivalent to synchronous reactance (Xd)
- Transient impedance (Zd') is equivalent to transient reactance (Xd')
- Subtransient impedance (Zd'') is equivalent to subtransient reactance (Xd'')

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The DataModel Owner/Submitter shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance information is provided.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.
Modeling of Generator Parameters

5. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

Generator Data

Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per testing requirements in SPP Planning Criteria 7.1.1 and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the sub unsaturated sub transient impedance for those generators modeled by sub transient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X"di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

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   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

Modeling Process for Generator Parameters

a. The Generator parameter P_MAX shall be modeled as a gross seasonal maximum capability based on MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.

b. Generating plant station service and auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All station service and auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus,
   ii. Corresponding to the voltage to which the auxiliary load is

15 Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant auxiliary load.
served. Model representations of auxiliary load connected to the generating unit bus (Figure VII-1), auxiliary load modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.

ii. Be annotated as non-scalable.

c. Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

If generating plant station service and auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use “SnS” in the Load ID field for one (Figure VII-4a). If there are more than one aggregated generating plant station service loads (Figure VII-4a) and auxiliary load, use “Sn” in the Load ID field to delineate the multiple aggregated loads.

If generating plant station service and auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “Fn” in the Load ID field\(^\text{16}\) to designate fixed load quantities that do not vary with plant dispatch.

\(^{16}\) “n” represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
ii. Use “Vn” in the Load ID field to designate variable load quantities that do vary with plant dispatch.

Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).

Only generating plant station service or auxiliary load IDs should be labeled with “Sn”, “Fn”, or “Vn” all other load types should be labeled differently.

Generating plant station service or auxiliary load IDs of “Sn” or “Vn” should be modeled such that the in-service status of the load follows the in-service status of the generator in which it is connected. For example: Generator 1 is offline, then the associated generating plant station service or auxiliary load with load IDs of “Sn” or “Vn” should also be offline.

d. The Generator Parameters for PMIN, AUX Load, QMAX, and QMIN shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

Modeling of Wind/Solar Renewable Resources $P_{GEN}$

- Spring Light Load Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility's latest five-year average (or replacement data if unavailable) for the SPP minimum load hour coincident Off-Peak hour corresponding to the season of the Light Load case, not to exceed each facility's firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility's long-term firm transmission service amount.

- On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility's latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility's firm service amount.

- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build. Any renewable resource modeling data submitted

17 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
to the PC, after the initial dispatch list is provided, will be dispatched at the initial seasonal state dispatch percentage of the renewable resource’s nameplate amount.

- When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

- Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

- For resources that do not have firm service, $P_{\text{gen}}$ values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

**Data Exemption Process**

MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the “Exemption Form” and send it via e-mail to “Engineering Modeling” containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.**

**Effective date of section 2 is July 1, 2016.**

**Effective date of section 4 is July 1, 2016.**

**Shortfall Guidance Process**

A shortfall is defined as an instance of insufficient firm resource to supply firm load. Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   e. The in-service date shall be based on the expected in-service date of the GI study.
f. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).

g. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of exploratory generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

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Remote Generation External Resource Modeling

Purpose
This procedure assures that members adhere to a uniform process when modeling remote generation external resources in SPP.

Modeling Process
If a member acquires remote generation external resources outside their Control Model Area (steady-state model numbered area), the following modeling process should be followed:

1. All buses should be assigned numbers that are in the host’s Control Model Area bus number range.
2. Area Number/Name should be the host’s Control Model Area number.
3. Zone Number/Name should be in the host’s Control Model Area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Owner Data and Line Mileage Data (SSAE Control)

To meet the SSAE requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:

1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic
messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
   Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
   The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.
a. **Voltage Summaries**

Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A. for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.
The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. QT --- MAX = one-half of MW rating
ii. QB --- MIN = negative one-third of MW rating

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
POI – Point Of Interconnection
MPT – Main Power Transformer
GSU – Generator Step-Up Transformer
N – Number of turbines/inverters/GSU transformers
# – Number of Modules/String
| – Solar Module

Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
**Periodic Model Updates**

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

**System Impact Studies/Expansion Options Studies (Long-Term)**
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

**MDWG Updates**
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI, IDEV format file to perform the RDCH operation. **This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.**

   **It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.**

The most current update to the models will always be posted on the SPP file sharing site.

**Program Operation**

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

**PTI-PSS®E Data Format**
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is **added** to the SPP steady-state models as specified in these format structures for records...
where no corresponding component is found in the model. The **modification** of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data for that bus will be removed (e.g., branches, transformers, generators, and loads). **The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified.** Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have “Area interchange control” with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with \( VHI – VLO < 0.005 \) per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**Steady-State Modeling Requirements**

**GENERATORS**

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters
and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.

2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the \( X_{\text{Source}} \) value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows in the ZSOURCE Table:

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS</th>
<th>ZSOURCE Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Synchronous</strong></td>
<td><strong>DC Armature Resistance (Ra)</strong> [PU*]</td>
<td><strong>Unsaturated sub-transient reactance</strong> ((X''_d)) [PU*]</td>
</tr>
<tr>
<td><strong>Non-Detailed, Classical or Transient</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Renewable – Wind Type 1</strong></td>
<td><strong>DC Armature Resistance (Ra)</strong> [PU*]</td>
<td><strong>Unsaturated transient reactance</strong> ((X'_d)) [PU*]</td>
</tr>
<tr>
<td><strong>Wind Type 2</strong></td>
<td></td>
<td>OR</td>
</tr>
<tr>
<td><strong>Renewable – Wind Type 3</strong></td>
<td><strong>DC Armature Resistance (Ra)</strong> [PU*]</td>
<td><strong>Unsaturated transient reactance</strong> ((X'_d)) of single machine [PU*]</td>
</tr>
<tr>
<td><strong>Solar PV</strong></td>
<td><strong>RS_Source = 0.0 [PU]</strong></td>
<td><strong>( V_{\text{rated}} = \text{Rated Voltage} )</strong> (= 1.0 \text{ [PU]} ) (assumed)</td>
</tr>
<tr>
<td><strong>Wind Type 4</strong></td>
<td></td>
<td><strong>( I_{\text{rated}} = \text{Rated Current From GO [PU]} )</strong></td>
</tr>
</tbody>
</table>
Renewable – Wind Type 5 | DC Armature Resistance (Ra) [PU*] | Unsaturated sub-transient reactance (X''d) [PU *]

\[ X_{Source} = \frac{V_{rated}}{I_{rated}} \] [PU]

* PU values should be based on the rated terminal voltage and machine MVA base

d. \( X_{Source} = X''d \) for detailed synchronous machine modeling

e. \( X_{Source} = X'd \) for non-detailed synchronous machine modeling

f. \( X_{Source} = \) should be equal to locked rotor impedance for an induction machine

g. \( X_{Source} = 1.0 \) per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation are available. If a user model representing particular SVC and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:

a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used

b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation

c. Different development phases
   i. These representations should be combined as the phases are placed in service as applicable

**OTHER DEVICES**

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and
should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV.
Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.
If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using \( R=0.00000 + X=0.00001 \) and \( B=0.00000 \). These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold \( \text{THRESH} \) in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of \( R=0.0001 + X=0.002 \) and \( B=0.00000 \). This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – Effective with Revision 28 of PSS®E, to adequately model transformers, the following parameters, at a minimum, are required:
   a. Nominal voltage of windings and bus reference to which the appropriate winding is connected
   b. Impedance(s)
   c. Tap ratios (voltage or phase angle)
   d. Minimum and maximum tap position limits
   e. Number of tap positions (for both the ULTC and NLTC)
   f. Regulated bus (for voltage regulating transformers)
   g. Ratings (normal and emergency)
   h. In-service status
   i. Vector group and Connection code

The measured impedance (resistive and inductive) between each pair of windings shall be specified: data entry options permit these to be entered in (1) per unit on system (100 MVA) base, (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage. Off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-
nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding.

8.9 Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

9.10 Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10.11 Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes. PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:

   a. Real-time operational auto or manual adjustment operation of the PST.
   b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
   c. Real-time operational MW flow limits (e.g. ±20 MW).
   d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
   e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
   f. Applicable long-term firm transmission service levels for the PST.

11.12 Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

12.13 AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.
13.14 Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

14.15 Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

15.16 Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16.17 Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

17.18 Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

18.19 Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

19.20 Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

20.21 Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

21. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should...
be represented as bus shunts. Fixed shunt elements that are directly connected to and
switch with a branch should be represented as line shunts.

22. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be
modeled explicitly. Continuous mode modeling using a switched shunt should not be used
unless it represents actual equipment (e.g. SVC or induction regulator). The number and
size of switched admittance blocks should represent field conditions. The bandwidth
(difference between VSWHIL and VSWLO) of switched shunt devices should be wide enough
that switching one block of admittance does not move the voltage at the bus completely
through the bandwidth, thus causing solution problems at the bus. It is recommended that
the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage.
Switched shunts should not regulate voltage at a generator bus, nor should they be
connected to the network with a zero impedance tie.

23.22. Static Var Systems – Static var elements should be modeled with accurate reactive power
(leading/lagging) limits. An accurate voltage set point and equipment status, as well as any
associated fixed/switched shunt equipment should also be modeled based on actual
seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service
status equal to zero. In-service Static Var Systems should be modeled with an in-service
status equal to one.

24.23. DC Transmission systems – DC transmission systems must be represented with a
sufficiently detailed model to simulate its expected behavior.

25.24. Interchange Tolerances – In a solved case, the actual interchange for any area containing a
Type 3 (swing) bus should be within 25 MW of the specified desired interchange value.
(Note that PSS®E does not enforce the interchange deviation for areas containing Type 3
buses.)

25. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas
directly connected solely by ties with flows controlled to a specific schedule (PAR-
controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. Other information requested by the PC or TP – Information which the PC or TP deems
necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in
series with it.
(Solution: If possible, add impedance of short and long series-connected lines and
represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines
are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal
point may have been misplaced, or large cutoff impedance was specified during
equivalencing.

4. A system’s regulating (slack) bus is in a different system. This is probably due to an
incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase
divergence will be flagged immediately and the program will stop calculating after
the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
a. Unequal voltage schedules at generating units connected by a low impedance line.
b. Regulation of a radial line at both ends at unequal voltages.
c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
d. Conflicting voltage regulation.
e. Unreasonably small voltage range for switched shunts.
f. Remote regulation of more than one bus away.

10. Not solvable from flat start.
11. Fictitious regulation of buses.
12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.
14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.
15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the “From” bus and the second-named bus is taken as the “To” bus. The “From” bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area. While typically analogous to a

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18 The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

19 Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\textsuperscript{20} loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

20 ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch ($P_{\text{gen}}$) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to as intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to as inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

Inter-area Bilateral transaction description
Data Owner A exports MW to Data Owner B
Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp. Entity #</th>
<th>From Resp. Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp. Entity #</th>
<th>To Resp. Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDW/G Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

Figure 3. Example of Inter-area transfer (transaction).
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.

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**Figure 4. Example of Intra-area transfer (transaction).**

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>XYZ112</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>XYZ112</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

**Intra-area Bilateral transaction description**

**Data Owner A** exports MW to **Data Owner C**

**Data Owner C** imports MW from **Data Owner A**
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where remote generation external resource is located to the generation owner control area. If the remote generation external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area’s number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

<table>
<thead>
<tr>
<th>No Transaction Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Area: XXX</td>
</tr>
<tr>
<td>Sink Area: YYY</td>
</tr>
<tr>
<td>Sink Load: XXX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transaction Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Area: XXX</td>
</tr>
<tr>
<td>Sink Area: YYY</td>
</tr>
<tr>
<td>Sink Load: YYY</td>
</tr>
</tbody>
</table>

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.
Transactions modeled in all base cases should be limited to expected firm schedules and should not include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models include full MMWG cases and machine reduced cases. These models reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPP reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the Regional Transmission Organization (SPP RTO) with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:

1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamics model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code (includes wind farms)
5. ERAG MMWG System Dynamics Database (SDDB)
6. SDDB data update worksheet

The schedule for submission of Dynamic data and list of MDWG Dynamic models (case types) can be found on the SPP corporate website, www.spp.org.

SPP MDWG Dynamic Models are published according to the schedule in Section 15 B.

1. The Dynamic data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Dynamics Model is also updated annually with current generator unit information. Steady-State models are used in conjunction with dynamic data to run dynamic simulation.

Dynamics Data Submittal Requirements and Guidelines

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The PSS®E dynamic model types classified as detailed are GENROU, GENSAL, GENROE, GENSAE, and GENDCO.

The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.

The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.
The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
   c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
   d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented. Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.
9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

### Procedures for Initialization and No-Disturbance Checks Of Library DYNAMICS Dynamics Cases

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   c. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   d. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or –9999.
   e. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      viii. Branches with extreme impedances or tap ratios [BRCH].
          Suggested options are:
          a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
          b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.

d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

f. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]

c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].

e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case.[SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)

a. Specify CONEC, CONET, and COMPile files.

b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using “user dynamics”.

a. Read converted load flow [CASE].
b. Read in the dynamic data file [DYRE]

c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.

d. Check consistency of dynamic models [DYCH, option 1].

e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.

   i. Warning messages for

      a) Generators in the load flow for which there is no active machine model.
      b) Models, usually of excitation systems or governors, initialized out of limits.
      c) The number of iterations required to initialize the initial-conditions steady-state.

   ii. A tabulation of conditions at each online machine

      a) Terminal voltage
      b) Exciter output voltage
      c) Real and reactive power output
      d) Power factor
      e) Machine angle in degrees
      f) Direct and quadrature axis currents on machine base.

   iii. A diagnosis of initial conditions, either

      a) “Initial conditions check OK”, or
      b) A listing of suspect initial conditions generally states whose time derivative is not “small” (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.

   iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of

   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).
14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((- K) = (-1 / R)\), mechanical power to \((1-1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

**Dynamic Data Format**

**PSS®E Users**
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyr file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

**Non-PSS®E Users**
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

NERC maintains a list of acceptable dynamic models on the NERC website for reference by the GO. Only NERC acceptable dynamic models from the latest approved list shall be provided the applicable TPs and to SPP, as PC, for dynamic model building purposes. The acceptable dynamic model list can be found on the NERC SAMS website ➔ SAMS Reference Materials ➔ NERC Acceptable Model List.

Dynamic models that are considered unacceptable by NERC, shall be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP

**Dynamics Data Validation Requirements**
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or
dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone
satisfactory initialization and 20-second no-disturbance simulation checks for each
dynamics case to be developed. The procedures outlined in Section III.H* of this manual
(*yet to be written) may be applied for this purpose.

Guidelines
1. Dynamics data submittals containing typical data should include documentation which identifies
those models containing typical data. The CON conservation models, such as GENROA and
GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this
purpose. When typical data is provided for existing devices, the additional documentation
should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal,
nuclear, combustion turbine, hydro, etc.).
2. The voltage dependency of loads should be represented as a mixture of constant impedance,
constant current, and constant power components (referred to as the ZIP model). The Regions
should provide parameters for representing loads via the PTI PSS®E CONL activity. These
parameters may be specified by area, zone, or bus. Other types of load modeling should be
provided to MMWG when it becomes evident that accurate representation of interregional
dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator
Regional Coordinators have two options, described below, for submitting dynamics data to the
MMWG Coordinator.

Dynamics Data Updates Using Excel Template
Regional dynamics data updates are incremental to the dynamics data in the previous year
release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in
SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.
The table below describes the various types of updates and the required data and information
that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
</tbody>
</table>
| Replace a model with another model of the same equipment group | Bus name, unit ID, model name for deleted model. | Yes for new model. | 1. A DC exciter is replaced by a static exciter.  
2. A classical machine model is replaced by a detailed model. |
| Change bus name and/or unit ID for all models of an existing unit | Old and new names; old and new unit IDs | No |  |
| Change bus number | No | No | Maintain the same name and unit ID and the model data will follow automatically. |
| Add dynamic models for a new generating unit | Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type | Yes | Same requirements whether unit is at new or existing bus. |
| Remove a unit and all associated models | Bus name, unit ID | No |  |

**Complete Set of Dynamics Data**
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

1. The Short Circuit data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators the positive, zero, and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Mutual Impedance

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground
current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line. Zero-sequence current is only present during ground faults, so the consideration of mutual coupling effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence fault current. It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.1

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSSE, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSSE models can be identified by checking when mutual impedance data is modeled and updated in a company’s primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

**Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).** The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the Reliability Steady-State MDWG Powerflow models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company's RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and

21 NERC Lesson Learned: Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements
transmission facilities to the Base MDWG Short Circuit model

2. Apply Classical assumptions

All transformers shall have a Vector Group and corresponding Connection Code in PSSE 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of the modeled sequence information prior to finalization.

Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.
SECTION 6: DEFINITIONS

These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner** – The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Data Submitter** – The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered is a power export and a negative value is considered a power import.

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22 Not a NERC functional entity
**Model Area** – The collection of model objects comprising an entity’s network and uniquely numbered in PSS®E.

**Peak Demand** – The highest demand including transmission losses for energy measured over a one clock hour period. 23

**PSS®E** – Siemens PTI’s Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

**PSS@E MOD** – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

**PSS@MOD File Builder** – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS@MOD Modeling projects by comparing PSS®E models.

**Transaction (Model)** – A modeled purchase and/or sale of power.

**Non-scalable load** – Load that does not conform to the daily load duration curve.

**On-Peak (Model)** – Those hours or other periods typically considered periods of higher electrical demand.

**Off-Peak (Model)** – Those hours or other periods typically considered periods of lower electrical demand.

**Regulating device** – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

**Shortfall** – Occurs when an entity does not have enough dispatchable generation to serve the entity’s load.

**Tie Line (Model)** – A circuit connecting two Model Areas.

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23 Attachment AA Resource Adequacy Section 2
SECTION 76: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,
From Area Name,
From Bus#,
From Bus Name,
From Bus kV,
To Region Name,
To Area#,
To Area Name,
To Bus#,
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI (pu),
BI (pu),
GJ (pu),
BJ (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

- In Service Date,
- Out Service Date,
- From Bus Region Name,
- From Bus Area#,
- From Bus Area Name,
- From Bus Number,
- From Bus Name,
- From Bus kV,
- To Bus Region Name,
- To Bus Area#,
- To Bus Area Name,
- To Bus Number,
- To Bus Name,
- To Bus kV,
- Tapped Side,
- CKT,
- CW,
- CZ,
- CM,
- MAG1,
- MAG2,
- Metered Side,
- NAME,
- STATUS (0,1),
- Owner 1,
- Fraction 1,
- Owner 2,
- Fraction 2,
- Owner 3,
- Fraction 3,
- Owner 4,
- Fraction 4,
- R1-2,
- X1-2,
- SBase1-2,
- WindV1,
- NomV1,
- Ang1,
- Summer Rating A1,
- Summer Rating B1,
- Summer Rating C1,
- Winter Rating A1,
- Winter Rating B1,
- Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RMI1,
VMA1,
VMI1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#,
Winding 1 Area Name,
Winding 1 Bus #,
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#,
Winding 2 Area Name,
Winding 2 Bus #,
Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#,
Winding 3 Area Name,
Winding 3 Bus #,
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBase2-3,
R3-1,
Three Winding Transformer Data Fields - continued

X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus #1(CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RMI1,
VMA1,
VMI1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued

RMI2,
VMA2,
VMI2,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RMI3,
VMA3,
VMI3,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields

In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (R,J),
DCVMIN,
CCCITMX,
CCCACC,
IPR REGION NAME,
IPR AREA#, 
IPR AREA NAME,
IPR Bus#,
IPR BUS NAME,
IPR BUS kV,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#, 
ICR AREA NAME,
ICR BUS#, 
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#, 
IFR AREA NAME,
IFR BUS#, 
IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME, 
ITR BUS KV, 
IDR, 
XCAPR, 
IPI REGION NAME, 
IPI AREA#, 
IPI AREA NAME, 
IPI Bus#, 
IPI BUS NAME, 
IPI BUS Kv, 
NBI, 
GAMMMX, 
GAMMMN, 
RCI, 
XCI, 
EBASI, 
TRI, 
TAPI, 
TMXI, 
TMNI, 
STPI, 
ICI REGION NAME, 
ICI AREA#, 
ICI AREA NAME, 
ICI BUS#, 
ICI BUS NAME, 
ICI BUS Kv, 
IFI REGION NAME, 
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IFI AREA NAME, 
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IFI BUS NAME, 
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ITI REGION NAME, 
ITI AREA#, 
ITI AREA NAME, 
ITI BUS#, 
ITI BUS NAME, 
ITI BUS KV, 
IDI, 
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements. 
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
## SECTION 87: APPENDIX III

**UTILIZED IMPEDANCE CORRECTION TABLES**

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SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice
Designating MOD-032-1 Data Submittal Assignment

On this _____ day of __________, 20___, __________________ and __________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following:

On __________________, 20___, __________________, Data Owner, and __________________, Data Submitter, entered into an agreement through which _____________________ has agreed to submit on behalf of _____________________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

__________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________

The accuracy of the data is the responsibility of the data owner. This notice does not shift the compliance obligation from the data owner to the data submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER:
By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: _______________

On behalf of DATA SUBMITTER:
By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: _______________
### SECTION 108: MOD-032-1 ATTACHMENT 1

**MOD-032-1 – ATTACHMENT 1**

The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnectionwide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
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<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
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<tr>
<td>(Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)</td>
<td>(If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</td>
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<tr>
<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
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<td>a. <strong>nominal voltage</strong></td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>a. Positive Sequence Data</td>
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<tr>
<td>b. <strong>area, zone and owner</strong></td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>b. Negative Sequence Data</td>
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<tr>
<td>a. <strong>real and reactive power</strong></td>
<td>5. Demand [LSE]</td>
<td>2. <strong>Mutual Line Impedance Data</strong> [TO]</td>
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<tr>
<td>b. <strong>in-service status</strong></td>
<td>6. Wind Turbine Data [GO]</td>
<td>3. <strong>Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes.</strong> [BA, GO, LSE, TO, TSP]</td>
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<td>3. Generating Units25 [GO, RP (for future planned resources only)]</td>
<td>7. Photovoltaic systems [GO]</td>
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<tr>
<td>a. <strong>real power capabilities - gross maximum and minimum values</strong></td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
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<tr>
<td>b. <strong>reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</strong></td>
<td>9. DC system models [TO]</td>
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<tr>
<td>c. <strong>station service auxiliary load for normal plant configuration (provide data in the same manner as that</strong></td>
<td>10. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling</td>
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</table>

24 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
<table>
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<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
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<td>e. machine MVA base</td>
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<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
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<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
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<td>h. in-service status*</td>
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<tr>
<td>4. AC Transmission Line or Circuit [TO]</td>
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<td>a. impedance parameters (positive sequence)</td>
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<td>b. susceptance (line charging)</td>
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<tr>
<td>c. ratings (normal and emergency)*</td>
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<tr>
<td>d. in-service status*</td>
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</tr>
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<td>5. DC Transmission systems [TO]</td>
<td></td>
</tr>
<tr>
<td>6. Transformer (voltage and phase-shifting) [TO]</td>
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<tr>
<td>a. nominal voltages of windings</td>
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<tr>
<td>b. impedance(s)</td>
<td></td>
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<tr>
<td>c. tap ratios (voltage or phase angle)*</td>
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<tr>
<td>d. minimum and maximum tap position limits</td>
<td></td>
</tr>
<tr>
<td>e. number of tap positions (for both the ULTC and NLTC)</td>
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<tr>
<td>f. regulated bus (for voltage regulating transformers)*</td>
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<td>g. ratings (normal and emergency)*</td>
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<td>7. Reactive compensation (shunt capacitors and reactors) [TO]</td>
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<tr>
<td>a. <strong>admittances (MVars) of each capacitor and reactor</strong></td>
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<tr>
<td>b. <em><em>regulated voltage band limits</em> (if mode of operation not fixed)</em>*</td>
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<td>c. <strong>mode of operation (fixed, discrete, continuous, etc.)</strong></td>
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<tr>
<td>d. <em><em>regulated bus</em> (if mode of operation not fixed)</em>*</td>
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</tr>
<tr>
<td>e. <strong>in-service status</strong>*</td>
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<table>
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<th>8. Static Var Systems [TO]</th>
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<tr>
<td>a. <strong>reactive limits</strong></td>
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<tr>
<td>b. <strong>voltage set point</strong>*</td>
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<tr>
<td>c. <strong>fixed/switched shunt, if applicable</strong></td>
</tr>
<tr>
<td>d. <strong>in-service status</strong>*</td>
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| 9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP] |
## REVISION HISTORY

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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, data owners, equipment, and data submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1), and the provisions of the

1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

### Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

A completed Letter of Notice identifying responsibilities between a Data Owner and a Data Submitter is required to be submitted to SPP. This Letter of Notice is included in the appendix section.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
**Applicable Equipment**

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.

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5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Sixth Revised Volume No.1, Attachment AI, Part II-1.
8 Sixth Revised Volume No.1, Attachment AI, Part II-2.
9 Sixth Revised Volume No.1, Part III-30.
10 Sixth Revised Volume No.1, Part III-31.
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- Appropriate lead times. Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes. In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
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</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models...
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

**Data Transmittal**
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- [GlobalScape](https://www.globalscape.com)
2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submission is through the “SPP MDWG File Sharing Site”, [GlobalScape](https://www.globalscape.com). Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP Model Release Guidelines**

**Steady-State and Short Circuit Models**
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the “Order Transmission Map/Model” quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables
Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   a. Steady-State RAWD case file
   b. Conversion IDEV files

2. Dynamics Cases
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group. GlobalScape under Modeling (CEII, RSD) → SPP Modeling Contacts → 3. Final Modeling Contacts

**NOTE** – A complete listing of other SPP acronyms can be found on the SPP website at [SPP Glossary](#).

Compliance

1. MDWG *Model Development Procedure Manual*
   Note: The latest document can be found on SPP.org

2. MDWG *Power flow, Short Circuit, and Dynamic model schedule and list*
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

1. The Steady-State data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, long name, and associated auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be not coincident to the SPP region, meaning that the hour that a Data Submitter's system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such
location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have an updated service agreement, or are in the process of finalizing a service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS® idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Not Coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

On-Peak/Off-Peak Models
Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority coincident peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
</tbody>
</table>

Typically 70% - 80% of Summer On-Peak load level

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.
Load Data
Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-3 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the EDST.

Area Summary Report
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**

Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member **must** coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting.
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**

Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The “from bus,” “to bus,” and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code.
The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conducance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional. The transformer tap and tap limits shall be specified. The use of LTC transformers should be kept to a minimum to help reduce the case solution time. Using LTC transformers for local area voltage control where no such transformer exists should be avoided. In general, regulating transformers should not be located at a bus with a regulating generator or other voltage regulating device; however, there may be exceptions based on current system topology and operating conditions.

6. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

7. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

8.1 Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase difference between windings, standardized with clock notation indicating phase displacement), and physical aspects of the transformer. This information is critical for accurately representing the transformer's behavior in the model.
conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

**NOTE:** When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

1. **Below 69 kV**
2. **69 kV**
3. **115 kV**
4. **138 kV**
5. **161 kV**
6. **230 kV**
7. **345 kV**
8. **500 kV**
9. **765 kV or above**

1. **For generator regulated buses, a desired voltage set point will be given.** Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1.

Generators shall model the gross output of the generating facility and explicitly model the station service auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the
system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.
**Generator Data**

Generating unit MW and MVAR output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per capability testing requirements in SPP Planning Criteria 7.1.1 and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with appropriate auxiliary load modeled explicitly. Generator reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit testing data and set appropriate to the modeled MW dispatch amount (PGEN). Energy storage (e.g., pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (PGEN) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour.

For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to ZSOURCE Table:

For dynamic simulation, **this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models**, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

For generating units with small X/R ratios (such as small, renewable units) the armature resistance (Ra) must be included in the generator model and, therefore, a resistive component of ZSOURCE must be greater than zero. However, if a synchronous unit has a sufficiently large X/R ratio, the value of ZR may be neglected, leading to the observations that:
- Synchronous impedance (Zd) is equivalent to synchronous reactance (Xd)
- Transient impedance (Zd') is equivalent to transient reactance (Xd')
- Subtransient impedance (Zd'') is equivalent to subtransient reactance (Xd'')

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance information is provided.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.

**Modeling of Generator Parameters**

5. Applicable Facilities - The following generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)
Generator Data
Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per testing requirements in SPP Planning Criteria 7.1.1 and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X''di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.

Modeling of Generator Parameters
1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

Modeling Process for Generator Parameters
a. The Generator parameter PMAX shall be modeled as a gross seasonal maximum capability based on SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.

b. Generating plant station service and auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All station service and auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus, corresponding to the voltage to which the auxiliary load is served. Model representations of auxiliary load connected to the generating unit bus (Figure VII-1), auxiliary load modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

12 Station service and auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant auxiliary load.
Experience has shown that generating plant station service and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant station service and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable station service and auxiliary load.

If generating plant station service and auxiliary load is \textit{aggregated}, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant station service and auxiliary load shall use “$S_n$” in the Load ID field for one or more aggregated generating plant station service loads (Figure VII-4a).

If generating plant station service and auxiliary load is \textit{not aggregated}, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant $P_{gen}$ may be less than $P_{max}$) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant station service and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “F$n$” in the Load ID field\(^\text{13}\) to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “V$n$” in the Load ID field\(^\text{4}\) to designate variable load quantities that do vary with plant dispatch.

\(^{13}\)“$n$” represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.

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Figure VII-1. Common bus representation  
Figure VII-2. Separate transformation representation  
Figure VII-3. Transformer high-side representation
Aggregated Auxiliary Load “Sn”

Combined Auxiliary Load (Fixed portion) “F1”

Combined Auxiliary Load (Variable portion) “V1”

Discrete Station Heater Auxiliary Load (Fixed) “F1”

Discrete Fuel Auger Auxiliary Load (Variable) “V1”

Discrete Station Lighting Auxiliary Load (Fixed) “F2”

Discrete Effluent Pump Auxiliary Load (Variable) “V2”

Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).

Only generating plant station service or auxiliary load IDs should be labeled with “Sn”, “Fn”, or “Vn”. All other load types should be labeled differently.

Generating plant station service or auxiliary load IDs of “Sn” or “Vn” should be modeled such that the in-service status of the load follows the in-service status of the generator in which it is connected. For example: Generator 1 is offline, then the associated generating plant station service or auxiliary load with load IDs of “Sn” or “Vn” should also be offline.

d. The Generator Parameters for PMIN, AUX Load, QMAX, and QMIN shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

Modeling of Wind/Solar Renewable Resources $P_{GEN}$

- Spring Light Load Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP minimum load hour corresponding to the season of the Light Load case, not to exceed each facility’s firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

- On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility’s firm service amount.

- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build. Any renewable resource modeling data submitted to the PC, after the initial dispatch list is provided, will be dispatched at the initial seasonal state dispatch percentage of the renewable resource’s nameplate amount.

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14 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
• When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

• Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

• For resources that do not have firm service, \( P_{CEN} \) values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

Data Exemption Process
MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the “Exemption Form” and send it via e-mail to “Engineering Modeling” containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.**
**Effective date of section 2 is July 1, 2016.**
**Effective date of section 4 is July 1, 2016.**

Shortfall Guidance Process
Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   e. The in-service date shall be based on the expected in-service date of the GI study.
   f. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).
   g. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of exploratory generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

External Resource Modeling

Purpose
This procedure assures that members adhere to a uniform process when modeling external resources in SPP.

Modeling Process
If a member acquires external resources outside their Model Area, the following modeling process should be followed:
1. All buses should be assigned numbers that are in the host’s Model Area bus number range.
2. Area Number/Name should be the host’s Model Area number.
3. Zone Number/Name should be in the host’s Model Area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Owner Data and Line Mileage Data (SSAE Control)

To meet the SSAE requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:
1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. Area Interchange
The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**  
The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**  
The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**  
Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**  
The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**  
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**
Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the \textit{CAP}/\textit{REAC} column of the steady-state report). The bandwidth (difference between \textit{VSWHI} and \textit{VSWLO}) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4\% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. \textbf{Summary of Overloaded Branches}

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. \textbf{Generation Summary}

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (\textit{MBASE}), and \textit{ZSOURCE} must be supplied for each generator. Generator \textit{FMAX} ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator \textit{MBASE} values should be equal to the nameplate \textit{MBASE} rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.
The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. \[ Q_T \rightarrow \text{MAX} = \text{one-half of MW rating} \]
ii. \[ Q_B \rightarrow \text{MIN} = \text{negative one-third of MW rating} \]

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
POI – Point Of Interconnection
MPT – Main Power Transformer
GSU – Generator Step-Up Transformer
N – Number of turbines/inverters/GSU transformers
K – Number of Modules/String

Solar Module

Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

   It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data
for that bus will be removed (e.g., branches, transformers, generators, and loads). The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified. Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have "Area interchange control" with the "Tie Line and Loads" option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**Steady-State Modeling Requirements**

**GENERATORS**

1. All steady-state generators, including synchronous condensers and Static VAR Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the
step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the ZSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

**ZSOURCE Table:**

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS</th>
<th>RSource (ZR)</th>
<th>XSource (ZX)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous – Detailed, Subtransient</td>
<td>DC Armature Resistance (Ra) [PU*]</td>
<td>Unsaturated sub-transient reactance (X''d) [PU*]</td>
<td></td>
</tr>
<tr>
<td>Synchronous – Non-Detailed, Classical or Transient</td>
<td>DC Armature Resistance (Ra) [PU*]</td>
<td>Unsaturated transient reactance (X') [PU*]</td>
<td></td>
</tr>
<tr>
<td>Renewable – Wind Type 1 Wind Type 2</td>
<td>DC Armature Resistance (Ra) [PU*]</td>
<td>Unsaturated transient reactance (X') of single machine [PU*]</td>
<td>OR Locked rotor reactance (sum of rotor and stator leakage reactances) [PU*]</td>
</tr>
<tr>
<td>Renewable – Wind Type 3</td>
<td>DC Armature Resistance (Ra) [PU*]</td>
<td>Unsaturated transient reactance (X') of single machine [PU*]</td>
<td></td>
</tr>
<tr>
<td>Renewable – Solar PV Wind Type 4</td>
<td>Source = 0.0 [PU]</td>
<td>Unsaturated sub-transient reactance (X''d) [Pu*]</td>
<td></td>
</tr>
<tr>
<td>Renewable – Wind Type 5</td>
<td>DC Armature Resistance (Ra) [PU*]</td>
<td>Unsaturated sub-transient reactance (X''d) [PU*]</td>
<td></td>
</tr>
</tbody>
</table>
* PU values should be based on the rated terminal voltage and machine MVA base. 

In accordance with PTI PSS®E requirements, the Xsource value in the steady-state generator data record shall be as follows:

d. $X_{source} = X''d$ for detailed synchronous machine modeling

e. $X_{source} = X' d$ for non-detailed synchronous machine modeling

f. $X_{source}$ should be equal to locked rotor impedance for an induction machine

g. $X_{source} = 1.0$ per unit or larger for all other devices

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation. If a user model representing particular SVC and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:

a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used

b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation

c. Different development phases

i. These representations should be combined as the phases are placed in service as applicable

Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator which hits a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E dynamic library models compatible with either representation are available. If a user model representing particular SVC and control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

OTHER DEVICES

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines,
reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 118.05, 110, 72, and 63.5 kV.
Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using $R=0.00000 + X=0.00001$ and $B=0.00000$. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of $R=0.0001 + X=0.002$ and $B=0.00000$. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches in Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – To adequately model transformers, the following parameters, at a minimum, are required:
   a. Nominal voltage of windings and bus reference to which the appropriate winding is connected:
      
      When entering transformer data, the rated voltage is for all applicable windings should be specified. For non-LTC transformers, the winding voltage should be set to the tap voltage.

      A recommended approach is to model three-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 1
      - X, or Low-Voltage, Winding = Winding 2

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15 Care should be taken to enter the rated voltage, which may be different than the nominal voltage of the system for all transformer windings. There can be a difference between the rated voltage of the system and the transformer (nominal).
A recommended approach is to model two-winding transformers such that the winding buses map to the transformer windings as follows:

- **Y**, or Tertiary-Voltage Winding = Winding 3
- **H**, or High-Voltage Winding = Winding 2
- **X**, or Low-Voltage Winding = Winding 1

The two-winding transformer winding map is in this order by default since PSSE requires all two-winding transformers with Load Tap Changers (LTCs) to specify the tap bus as Winding 1. While not all LTC transformers have the tap on the X winding, this is common with most transformers.

**b. Impedance(s):**

A recommended approach to modeling transformer impedance is to set the winding MVA base to the system MVA base which is 100 MVA, entered as positive sequence data in pairwise (delta) format. Care should be taken to when entering transformer impedance data to ensure that the data entered corresponds to the appropriate base (system or winding).

Enter zero sequence data in the format appropriate to the connection code.

**Connection codes <10:**
- The zero sequence data must be entered as T-model format

**Connection codes >10:**
- The zero sequence data must be entered in pairwise (delta) format

**h.c. Tap ratios (voltage or phase angle)**

**i.d. Minimum and maximum tap position limits**

**e. Number of tap positions (for both ULTC and NLTC)**

- Automatically adjusting, on-load tap changers (ULTC) control bus and tap positions shall be specified.
- Non-automatically adjusting on-load tap changers (ULTC) control bus and total number of tap positions shall be specified.
- Transformer tap positions are discrete. The total number of transformer tap positions is a fixed quantity and shall be entered. The maximum and minimum transformer tap positions represent the physical boundaries of the transformer’s capability to modify its winding impedance to achieve a control objective. Transformer tap changing control modes may include voltage regulation, as well as real and reactive power control. Automatically-adjusting on- or under-load tap changing transformers (ULTC) shall specify a control mode, the bus that is being controlled, and the control limits defined by the maximum and minimum transformer tap positions.

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16 Two winding representation in PSSE allows the user to select which bus number (from or to) the winding 1 resides.

17 It is noted that PSSE provides transformer tap changer limit fields called VMAX and VMIN, regardless of control mode. For example, if a real power control mode is selected, the user must enter MW quantities in the VMAX and VMIN fields.
Regulated bus (for voltage regulating transformers)

Ratings (normal and emergency)

In-service status

Vector group and Connection code

- The vector group shall match the topological configuration of the buses representing where the windings are connected (e.g., a 115/69 kV load-serving transformer with a vector group of Dyn11 must show the winding 1 bus [Delta winding] as the 115 kV bus).

- Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

The measured impedance (resistive and inductive) between each pair of windings shall be specified; data entry options permit these to be entered in (1) per unit on system (100 MVA) base, (2) per unit on winding MVA base, or (3) load loss in watts and impedance on winding MVA base and base voltage. Off-nominal turns ratios may not be specified for branches; a block of four or five data records must be entered for each transformer. The off-nominal turns ratio in per unit, or the actual winding voltage in kilovolts, and the phase shift in degrees shall be specified for each winding.

Transformers Controlling Voltage or Reactive Power Flow – The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling voltage or reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower voltage limits are entered for transformers controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes.

18 Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes
PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:

a. Real-time operational auto or manual adjustment operation of the PST.
b. Real-time operational average MW flow for a particular season (e.g., average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
c. Real-time operational MW flow limits (e.g., ±20 MW).
d. Real-time operational phase shift angle range (e.g., -52.9° to 31.4°).
e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
f. Applicable long-term firm transmission service levels for the PST.

12. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

13. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

14. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

15. Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

16. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is
explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

17. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

18. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

19. Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

20. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

21. Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

22. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

23. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

24. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service status.
equal to zero. In-service Static Var Systems should be modeled with an in-service status equal to one.

25. DC Transmission systems – DC transmission systems must be represented with a sufficiently detailed model to simulate its expected behavior.

26. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

27. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

28. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it.
   (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during equivalencing.

4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. fictitious regulation of buses.

12. Extremely low voltage schedules.

13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.
15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area. While typically analogous to a

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19 The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

20 Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\(^2\) loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

\[\text{Figure 1. Example of interconnected model areas.}\]

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\(^2\) ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (Pgen) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:

Figure 2. Four types of inter-SPP pseudo-ties.
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

Data Owner A

Physical circuitry tie is irrelevant.

Source

Data Owner B

Sink

Inter-area Bilateral transaction description

Data Owner A exports MW to Data Owner B
Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>Data Series</th>
<th>PCMDWG</th>
<th>Model</th>
<th>Spec</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3. Example of Inter-area transfer (transaction).
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where external resource is located to the generation owner control area. If the external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area's number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

No Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC's ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPP reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the SPP RTO with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:
1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamic model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code
5. The schedule for submission of Dynamic data and list of MDWG Dynamic models [case types] can be found on the SPP corporate website, www.spp.org.

Dynamics Data Submittal Requirements and Guidelines
1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.
   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.
   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.
2. All synchronous generators and condensers modeled in detail per Requirement I.1 shall also include representations of the excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented. Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

9. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

10. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.
Procedure for Initialization and No-Disturbance Checks Of Library Dynamics Cases

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   c. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   d. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or −9999.
   e. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      vii. Overloaded generators. [GEOI]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      viii. Branches with extreme impedances or tap ratios [BRCH].
   Suggested options are:
      a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
      b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
      c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.
      d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.
      e) High tap ratios.
      f) Low tap ratios.
Interactive checks: the user is asked to enter new value(s) for each exception, or hit "carriage return" for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in "islands" not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.
   a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]
   b. Read in the raw data file just created. [READ]
   c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]
   d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE]
   e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)
   a. Specify CONEC, CONET, and COMPILE files.
   b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using "user dynamics".
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE]
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
b) Models, usually of excitation systems or governors, initialized out of limits.
c) The number of iterations required to initialize the initial-conditions steady-state.

   ii. A tabulation of conditions at each online machine
   a) Terminal voltage
   b) Exciter output voltage
   c) Real and reactive power output
   d) Power factor
   e) Machine angle in degrees
   f) Direct and quadrature axis currents on machine base.

   iii. A diagnosis of initial conditions, either
   a) “Initial conditions check OK”, or
   b) A listing of suspect initial conditions generally states whose time derivative is not
      “small” (relative to the value of the state). These may be caused by inconsistencies
      between the real and reactive power scheduled for a unit by the load flow
      (including automatic changes in reactive power to hold bus voltage at a target
      level) or by parameter errors.

   iv. For models flagged in steps i) through iii), consider using activity
      [DOCU] to identify parameters which may be causing problems.
      This activity will also give the automatically calculated values of
      exciter model parameters, which are derived if the corresponding
      parameters, as read in, are 0. Other warnings may indicate errors
      in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point
   until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance
    or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence
    monitor [RUN,CM] can indicate where problems are, but considerably increases the
    amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.
13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field
    voltage and terminal voltage will be output for each exciter model and may be reviewed
    in tabular or graphical form. Satisfactory response is indicated if the terminal voltage
    settles to the specified value within a few seconds, if the field voltage is reasonable, and
    the response is free of
    a. Excessive overshoot
    b. Sustained oscillations
    c. High frequency noise (may be caused by using too long a simulation time step.)
    d. Unexpected discontinuities in the output variables or their derivatives [except IEEE Type 4
       “non-continuous” regulator models].

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical
    power and speed deviation will be output for each shaft where a governor model is
    present and may be reviewed in tabular or graphical form. Models of cross-compound
    unit governors specify two machines so four output variables are used. Steam or
    combustion turbine unit governors may require up to 20 seconds to attain equilibrium,
    and hydro units even longer, even if they are well tuned. Satisfactory response is
    indicated if speed deviation settles to approximately (- K) = (-1 / R), mechanical power to
    (1-1/K) times the specified value, and the response variables are free of excessive
    overshoot or sustained oscillations.
Dynamic Data Format

PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

Non-PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

NERC maintains a list of acceptable dynamic models on the NERC website for reference by the GO. Only NERC acceptable dynamic models from the latest approved list shall be provided the applicable TPs and to SPP, as PC, for dynamic model building purposes. The acceptable dynamic model list can be found on the NERC SAMS website → SAMS Reference Materials → NERC Acceptable Model List.

Dynamic models that are considered unacceptable by NERC, shall be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:
1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP

Dynamics Data Validation Requirements
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.
**Guidelines**

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).

2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

**Procedures for Submission of Dynamics Data to the MMWG Coordinator**

Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

**Dynamics Data Updates Using Excel Template**

Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.

The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>dynamics model</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another model of</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes for new model.</td>
<td>1. A DC exciter is replaced by a static exciter.</td>
</tr>
<tr>
<td>the same equipment group</td>
<td></td>
<td></td>
<td>2. A classical machine model is replaced by a detailed model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>models of an existing unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Change bus number</td>
<td>No</td>
<td>No</td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
</tr>
<tr>
<td>-------------------</td>
<td>----</td>
<td>----</td>
<td>---------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
<td>Same requirements whether unit is at new or existing bus.</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Complete Set of Dynamics Data**
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

1. The Short Circuit data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators the positive and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project. The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Mutual Impedance

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line. Zero-sequence current is only present during ground faults, so the consideration of mutual coupling...
effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence fault current. It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.22

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSSE, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSSE models can be identified by checking when mutual impedance data is modeled and updated in a company’s primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

**Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).** The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the MDWG Powerflow models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

22 **NERC Lesson Learned: Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements**
All transformers shall have a Vector Group and corresponding Connection Code in PSSE 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of the modeled sequence information prior to finalization.

Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.
SECTION 6: DEFINITIONS

These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner** – The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**DataSubmitter** – The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered a power export and a negative value is considered a power import.

23 Not a NERC functional entity
**Model Area** – The collection of model objects comprising an entity’s network and uniquely numbered in PSS®E.

**Peak Demand** – The highest demand including transmission losses for energy measured over a one clock hour period.

**PSS®E** – Siemens PTI’s Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

**PSS®E MOD** – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

**PSS®MOD File Builder** – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS®MOD Modeling projects by comparing PSS®E models.

**Transaction (Model)** – A modeled purchase and/or sale of power.

**Non-scalable load** – Load that does not conform to the daily load duration curve.

**On-Peak (Model)** – Those hours or other periods typically considered periods of higher electrical demand.

**Off-Peak (Model)** – Those hours or other periods typically considered periods of lower electrical demand.

**Regulating device** – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

**Shortfall** – Occurs when an entity does not have enough dispatchable generation to serve the entity’s load.

**Tie Line (Model)** – A circuit connecting two Model Areas.

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24 Attachment AA Resource Adequacy Section 2
SECTION 7: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

- In Service Date,
- Out Service Date,
- From Region Name,
- From Area#,
- From Area Name,
- From Bus#,
- From Bus Name,
- From Bus kV,
- To Region Name,
- To Area#,
- To Area Name,
- To Bus#,
- To Bus Name,
- To Bus kV,
- Metered End (F,T),
- CKT,
- R,
- X,
- B,
- Summer Rating A,
- Summer Rating B,
- Summer Rating C,
- Winter Rating A,
- Winter Rating B,
- Winter Rating C,
- Gl (pu),
- Bi (pu),
- Gj (pu),
- Bj (pu),
- STATUS (0,1),
- LEN (mi),
- Owner 1,
- Fraction 1,
- Owner 2,
- Fraction 2,
- Owner 3,
- Fraction 3,
- Owner 4,
- Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#, 
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#, 
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT, 
CW, 
CZ, 
CM, 
MAG1, 
MAG2, 
Metered Side,
NAME, 
STATUS (0,1), 
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2, 
X1-2, 
SBase1-2, 
WindV1, 
NomV1, 
Ang1, 
Summer Rating A1, 
Summer Rating B1, 
Summer Rating C1, 
Winter Rating A1, 
Winter Rating B1, 
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM1,
VMA1,
VM1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date, 
Out Service Date, 
Winding 1 Region Name, 
Winding 1 Area#, 
Winding 1 Area Name, 
Winding 1 Bus#, 
Winding 1 Bus Name, 
Winding 1 Bus kV, 
Winding 2 Region Name, 
Winding 2 Area#, 
Winding 2 Area Name, 
Winding 2 Bus#, 
Winding 2 Bus Name, 
Winding 2 Bus kV, 
Winding 3 Region Name, 
Winding 3 Area#, 
Winding 3 Area Name, 
Winding 3 Bus#, 
Winding 3 Bus Name, 
Winding 3 Bus kV, 
CKT, 
CW, 
CZ, 
CM, 
MAG1, 
MAG2, 
NMETR(1,2,3), 
NAME, 
STATUS(0,1), 
Owner 1, 
Fraction 1, 
Owner 2, 
Fraction 2, 
Owner 3, 
Fraction 3, 
Owner 4, 
Fraction 4, 
R1-2, 
X1-2, 
SBase1-2, 
R2-3, 
X2-3, 
SBASE2-3, 
R3-1,
Three Winding Transformer Data Fields - continued

X3-1, SBASE3-1, VMSTAR, ANSTAR, WindV1, NomV1, Ang1, Summer Rating A1, Summer Rating B1, Summer Rating C1, Winter Rating A1, Winter Rating B1, Winter Rating C1, COD1, Control Bus 1 Region, Control Bus 1 Area Number, Control Bus 1 Area Name, Control Bus #(CONT1), Control Bus Name, Control Bus KV, RMA1, RM1, VMA1, VM1, NTP 1, TAB1, CR1, CX1, WindV2, NomV2, Ang2, Summer Rating A2, Summer Rating B2, Summer Rating C2, Winter Rating A2, Winter Rating B2, Winter Rating C2, COD2, Control Bus 2 Region, Control Bus 2 Area Number, Control Bus 2 Area Name, CONT2, Control Bus 2 Name, Control Bus 2 KV, RMA2,
Three Winding Transformer Data Fields - continued
RM12,
VMA2,
VM12,
NTP 2,
TAB 2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RM3,
VMA3,
VM3,
NTP 3,
TAB 3,
CR3,
CX3
Two Terminal DC Tie Data Fields

In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (R,l),
DCVMIN,
CCCTMX,
CCCACC,
IPR REGION NAME,
IPR AREA#, 
IPR AREA NAME,
IPR Bus#,
IPR BUS NAME,
IPR BUS Kv,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
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IFR BUS NAME,
IFR BUS kV,
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ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS #,
ITR BUS NAME,
ITR BUS KV,
IDR,
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IP1 REGION NAME,
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ITI BUS NAME,
ITI BUS KV,
IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
### SECTION 8: APPENDIX II

**UTILIZED IMPEDANCE CORRECTION TABLES**

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</table>
SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice
Designating MOD-032-1 Data Submittal Assignment

On this _____ day of __________, 20____, ______________ and ______________, provide notice to Southwest Power Pool Inc. (SPP) of the following:

On ______________, 20____, ______________, Data Owner, and ______________, Data Submitter, entered into an agreement through which ______________ has agreed to submit on behalf of ______________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

________________________________________________________________________________________________________________
________________________________________________________________________________________________________________
________________________________________________________________________________________________________________

The accuracy of the data is the responsibility of the data owner. This notice does not shift the compliance obligation from the data owner to the data submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER:    SPP hereby acknowledges receipt of this notice.
By: ______________________________    By: ______________________________
Printed Name: _____________________   Printed Name: _____________________
Title: _____________________________   Title: _____________________________
Date: _______________     Date: _________________

On behalf of DATA SUBMITTER:

By: ______________________________
Printed Name: ________________
Title: _________________________
Date: ______________
### SPP MOD Project Type/Status Matrix

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Notes</th>
</tr>
</thead>
</table>
| SPP-approved Transmission System Upgrade | Main have as NTC for: 1) transmission service request(s); 2) transmission changes originating from the integrated transmission planning (ITP) process; 3) transmission changes originating from the Balanced Portfolio process; 4) transmission changes directed by the high priority study process; 5) transmission changes associated with Sponsored Upgrades. | Approved | Transmission changes that materially modify the SPP transmission System - Projects associated with changing the generation or load components interconnected to the SPP Transmission System in accordance with SPP ITP Attachment V and AG processes - are submitted separately under the “Generation Interconnection” or “Attachment AG Load” MOD Types. | MDWG X
| | | | | ITP X
| | | | | GI X
| | | | | Special Study X |
| Planned Transmission System Change | Be expected change to the SPP Transmission System that does not yet have or does not require an NTC, including: 1) transmission changes budgeted for or planned by the TO; 2) transmission changes budgeted for by a Transmission Customer or other entity; 3) transmission changes resulting from an emergency (e.g., unplanned equipment failure); 4) transmission, load, or generation changes that otherwise have a strong likelihood or commitment to implementation (e.g., load changes not yet approved by Attachment AQ, a GI with an A but on suspension, a GI without an A, etc.). | Requested | For material changes, Data Submitters shall submit an RMS ticket as a way of notifying SPP. The status of these projects may be changed to “Acknowledged” only by Data Submitters after receiving a notification from SPP. Projects associated with changing the generation or load components interconnected to the SPP Transmission System in accordance with SPP ITP Attachment V and AG processes - are submitted separately under the “Generation Interconnection” or “Attachment AG Load” MOD Types. | MDWG X
| | | | | ITP X
| | | | | GI X
| | | | | Special Study X |
| Attachment AQ | Changes to lead and/or delivery points approved in accordance with Attachment AQ, including any transmission changes associated with the Attachment AQ project (e.g., equipment upgrades, changes to normally-open/closed topologies). | Approved | Transmission changes that materially modify the SPP transmission System - Projects associated with changing the generation or load components interconnected to the SPP Transmission System in accordance with SPP ITP Attachment V and AG processes - are submitted separately under the “Generation Interconnection” or “Attachment AG Load” MOD Types. | MDWG X
| | | | | ITP X
| | | | | GI X
| | | | | Special Study X |
| Generation Interconnection | Additions or changes to generating units, including any transmission changes associated with the Generation Interconnection Service project(s), approved in accordance with the Generation Interconnection Procedure (GIP) that: 1) have an executed Interconnection Agreement (IA) or executed Interim Generator Interconnection Agreement (IGIA), and 2) are not suspended. | Approved | Generation changes and transmission changes, including upgrades that may not have been included in the executed IA, associated with changing the generation or load components interconnected to the SPP Transmission System in accordance with SPP ITP Attachment V and AG processes - are submitted separately under the “Generation Interconnection” or “Attachment AG Load” MOD Types. | MDWG X
| | | | | ITP X
| | | | | GI X
| | | | | Special Study X |
| Network Status | Changes to the existing SPP Transmission System network topological status only (both placed out-of-service or returned to service). | Update | Projects with this status will be immediately committed to the MOD base case upon review. | MDWG X
| | | | | ITP X
| | | | | GI X
| Model Year | Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD network data. | Update | Projects with this status will not be applied to any models except those models submitted to MMWG. | MDWG X
| | | | | ITP X
| | | | | GI X
| System Intact Alteration | Changes to the transmission model necessary to correct basecase system-intact voltage (e.g., to conform to MMWG voltage criteria, thermal criteria violations, or other basecase condition modifications (e.g., addition of an exploratory generating unit which provided resource for another). | Update | Projects with this status will not be applied to any models except those models submitted to MMWG. | MDWG X
| | | | | ITP X
| | | | | GI X
| | | | | Special Study X |
The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state (Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)</th>
<th>dynamics (If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</th>
<th>short circuit</th>
</tr>
</thead>
</table>

---

25 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
data in the same manner as that required for aggregate Demand under item 2, above)

d. regulated bus* and voltage set point* (as typically provided by the TOP)

e. machine MVA base

f. generator step up transformer data (provide same data as that required for transformer under item 6, below)

g. generator type (hydro, wind, fossil, solar, nuclear, etc)

h. in-service status*

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<tr>
<th>4. AC Transmission Line or Circuit [TO]</th>
<th>5. DC Transmission systems [TO]</th>
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<tbody>
<tr>
<td>a. impedance parameters (positive sequence)</td>
<td>d. in-service status*</td>
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<tr>
<td>b. susceptance (line charging)</td>
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<tr>
<td>c. ratings (normal and emergency)*</td>
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<tr>
<td>d. in-service status*</td>
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<th>6. Transformer (voltage and phase-shifting) [TO]</th>
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<tr>
<td>b. impedance(s)</td>
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<tr>
<td>c. tap ratios (voltage or phase angle)*</td>
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<tr>
<td>d. minimum and maximum tap position limits</td>
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<tr>
<td>e. number of tap positions (for both the ULTC and NLTC)</td>
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<tr>
<td>f. regulated bus (for voltage regulating transformers)*</td>
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<tr>
<td>g. ratings (normal and emergency)*</td>
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<tr>
<td>h. in-service status*</td>
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</table>
7. Reactive compensation
   (shunt capacitors and reactors) [TO]
   a. admittances (MVAr) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GD, LSE, TO, TSP]
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, Data Owners, equipment, and Data Submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1)1, and the provisions of the

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1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

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2 Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

3 For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

A completed Letter of Notice identifying responsibilities between a Data Owner and a Data Submitter is required to be submitted to SPP. This Letter of Notice is included in the appendix section.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.

5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Sixth Revised Volume No.1, Attachment AI, Part II-1.
8 Sixth Revised Volume No.1, Attachment AI, Part II-2.
9 Sixth Revised Volume No.1, Part III-30.
10 Sixth Revised Volume No.1, Part III-31.
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

Accountability

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes.** In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP. The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models.
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

**Data Transmittal**
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- GlobalScape
2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the “SPP MDWG File Sharing Site”, GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP Model Release Guidelines**

**Steady-State and Short Circuit Models**
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables
Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   a. Initialized steady state and regional contingency cases.
   b. Steady-State RAWD case file
   c. Conversion IDEV files

2. Dynamics Cases
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP’s GlobalScape under Modeling (CEII, RSD) → SPP Modeling Contacts → 3. Final Modeling Contacts

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

Compliance

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

1. The Steady-State data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, long name, and associated Auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts that meet TPL-001 requirements with a duration of at least six months shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be not Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak
hours without manual intervention. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have an updated service agreement, or are in the process of finalizing a service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS®E idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Not Coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

On-Peak/Off-Peak Models
Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority Coincident Peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
</tbody>
</table>

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit
load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.

**Load Data**

Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. Refer to Section 5-A-2 for load data formats. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID “R1”). These loads should be maintained in the Load Mapping worksheet of the EDST.

**Area Summary Report**

The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing
machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.

7. The case year and season should be entered in the appropriate locations in chronological order.

8. The current system official load forecast should be entered as net load (Item 6).

9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.

10. Load equals net load minus estimated losses (Item 4).

11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**

Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**

Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model. The line and transformer data formats are found in Section 5.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The “from bus,” “to bus,” and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which
The “from bus” is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional.

6. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit milesages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

7. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

Bus Data
For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one
series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

**NOTE:** When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

<table>
<thead>
<tr>
<th>Voltage Band</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Below 69 kV</td>
<td>1</td>
</tr>
<tr>
<td>2 - 69 kV</td>
<td>2</td>
</tr>
<tr>
<td>3 - 115 kV</td>
<td>3</td>
</tr>
<tr>
<td>4 - 138 kV</td>
<td>4</td>
</tr>
<tr>
<td>5 - 161 kV</td>
<td>5</td>
</tr>
<tr>
<td>6 - 230 kV</td>
<td>6</td>
</tr>
<tr>
<td>7 - 345 kV</td>
<td>7</td>
</tr>
<tr>
<td>8 - 500 kV</td>
<td>8</td>
</tr>
<tr>
<td>9 - 765 kV or above</td>
<td>9</td>
</tr>
</tbody>
</table>

1. For generator regulated buses, a desired voltage set point will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the Station Service or Auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for
local area voltage support, rather than falsely regulating a bus. Attention should be
given to these installations in cases that are referencing a different season model.
Tertiary reactors should be modeled on the low voltage bus of transformers if the
tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the
Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt
voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state
solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts
with specified B initial value.
Generator Data
Generating unit MW and MVAR output shall be submitted such that the unit is within the
PMAX, PMIN, QMAX, QMIN and MVA base limits per capability testing requirements in MOD-025-2
and SPP Planning Criteria 7.1.1. Generator real power rated capability shall be set to the gross
maximum and minimum values (PMAX and PMIN) with appropriate auxiliary load modeled
explicitly. Generator rated reactive power capability maximum and minimum values (QMAX and
QMIN) in the models should be based on unit testing data and set appropriate to the modeled MW
dispatch amount (PGEN). Energy storage (e.g., pumped hydro, battery, flywheel, etc.) shall be
modeled with the generator rated capabilities and a dispatch amount (PGEN) no greater than the
rated output that can be sustained continuously for a minimum of one (1) hour.

- For steady state analysis, the synchronous impedance of a generating unit is not used in load flow
calculations. However, the representation for complex machine impedance for the generating unit,
called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a
critical parameter in performing switching studies, fault analysis, and dynamic simulations.
ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall
ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data
Record according to ZSOURCE Table.

For dynamic simulation, this complex impedance must be set equal to the unsaturated
subtransient impedance for those generators modeled by subtransient level machine
tables, and to transient impedance for those modeled by classical or transient level models.
Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-
state models must match dynamic data and should be established through manufacturer data or
generator testing. Future Generators that are in the models but are not budgeted for construction
need to be identified in the Generator Data worksheet of the EDST.

For generating units with small X/R ratios (such as small, renewable units) the armature resistance
(Ra) must be included in the generator model and, therefore, a resistive component of ZSOURCE
must be greater than zero. However, if a synchronous unit has a sufficiently large X/R ratio, the
value of ZR may be neglected, leading to the observations that:
- Synchronous impedance (Zd) is equivalent to synchronous reactance (Xd)
- Transient impedance (Zd') is equivalent to transient reactance (Xd')
- Subtransient impedance (Zd'') is equivalent to subtransient reactance (Xd'')

For synchronous machines, the short circuit model should be comprised of saturated transient and
subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated
transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable)
grounding impedance data. This data shall be entered into the generator Sequence Impedance Data
Record. In some cases, resistances for units may be assumed negligible, as long as reactance
information is provided.

When modeling mothballed and future retired units, the PMax, PMin, QMax, and QMin values
should be modeled as zero. The unit will be modeled offline (in-service status = 0) similar to units
that are not dispatched in the particular seasonal model. Unit retirement information will be
provided in a separate document and posted through a secure website. Decommissioned units
should be removed from the models.

Modeling of Generator Parameters
5. Applicable Facilities - The following generators and SVCs connected to BES (100 kV
and greater) or in accordance with the SPP OATT or Member OATT.
a. All Individual units greater than 20 MVA (gross nameplate rating)
b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

Generator Data
Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per testing requirements in SPP Planning Criteria 7.1.1 and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with Aauxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities. Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + jZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X''di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

When modeling mothballed and future retired units, the Pmax, Pmin, Qmax, and Qmin values should be modeled as zero. Decommissioned units should be removed from the models.

Modeling of Generator Parameters
1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT.
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

Modeling Process for Generator Parameters
a. The Generator parameter PMAX shall be modeled as a gross seasonal maximum capability based on SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.

b. Generating plant Station Service load and Aauxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All Station Service load Station service and Aauxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus, corresponding to the voltage to which the Aauxiliary load is served. Model representations of Aauxiliary load connected to the generating unit bus (Figure VII-1), Aauxiliary load.

11 Station Service load and Aauxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant Aauxiliary load Aauxiliary load.
modeled with separate transformation (Figure VII-2), and auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.

ii. Be annotated as non-scalable.

c. Experience has shown that generating plant Station Service load and auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant Station Service load and auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable Station Service load and auxiliary load.

If generating plant Station Service load and auxiliary load is aggregated, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant Station Service load and auxiliary load shall use "S\n" in the Load ID field for one or more aggregated generating plant Station Service load and auxiliary load (Figure VII-4a).

If generating plant Station Service load and auxiliary load is not aggregated, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant P\text{gen} may be less than P\text{max}) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant Station Service load and auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “F\n” in the Load ID field to designate fixed load quantities that do not vary with plant dispatch.

12 \( \text{n} \) represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
ii. Use \( \text{Vn} \) in the Load ID field to designate variable load quantities that do vary with plant dispatch.

- **Aggregated Auxiliary Load** \( \text{S}_n \)
- **Combined Auxiliary Load** (Fixed portion) \( \text{F}_1 \)
- **Combined Auxiliary Load** (Variable portion) \( \text{V}_1 \)
- **Discrete Station Heater Auxiliary Load** (Fixed) \( \text{F}_2 \)
- **Discrete Fuel Auger Auxiliary Load** (Variable) \( \text{V}_2 \)
- **Discrete Station Lighting Auxiliary Load** (Fixed) \( \text{F}_3 \)
- **Discrete Effluent Pump Auxiliary Load** (Variable) \( \text{V}_3 \)

Figure VII-4. Examples of generating plant auxiliary load representations (aggregated, combined, and discrete).

Only generating plant Station Service or auxiliary load IDs should be labeled with \( \text{S}_n, \text{F}_n, \) or \( \text{V}_n \). All other load types should be labeled differently.

Generating plant Station Service or auxiliary load IDs of \( \text{S}_n \) or \( \text{V}_n \) should be modeled such that the in-service status of the load follows the in-service status of the generator in which it is connected. For example: Generator 1 is offline, then the associated generating plant Station Service or auxiliary load with load IDs of \( \text{S}_n \) or \( \text{V}_n \) should also be offline.

- **d.** The Generator Parameters for \( \text{P}_\text{MIN}, \text{AUX Load}, \text{QMAX}, \) and \( \text{QMIN} \) shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

**Modeling of Wind/Solar Renewable Resources \( \text{P}_\text{GEN} \)**

- **Spring Light Load Off-Peak models:** Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP minimum load hour corresponding to the season of the Light Load case, not to exceed each facility’s firm service amount. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

- **On-Peak & Summer Shoulder Off-Peak models:** Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility’s firm service amount.

- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model.

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13 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
pass of the each SPP MDWG model build. Any renewable resource modeling data submitted to the PC, after the initial dispatch list is provided, will be dispatched at the seasonal state dispatch percentage of the renewable resource's nameplate amount.

- When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.
- Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.
- For resources that do not have firm service, $P_{GEN}$ values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable, then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

Data Exemption Process
MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the "Exemption Form" and send it via e-mail to "Engineering Modeling" containing:
   a. Generator Name
   b. Generator Bus Number
   c. Requested change(s) that deviate from the MOD-025-02/SPP Planning Criteria testing.
   d. Justification of the change if it is greater than or less than 5% of the MOD-025-02/SPP Planning Criteria testing.

SPP Modeling will process the Exemption and communicate back to the member requesting the exemption that it has been granted or if additional information is needed to process the exemption within 30 days of submission of the request.

**Effective date of sections 1&3 is in effect.**
**Effective date of section 2 is July 1, 2016.**
**Effective date of section 4 is July 1, 2016.**

Shortfall Guidance Process
Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.
2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements:
   a. The in-service date shall be based on the expected in-service date of the GI study.
f. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).

g. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future exploratory generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future exploratory generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, exploratory generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of exploratory generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

External Resource Modeling
Purpose
This procedure assures that members adhere to a uniform process when modeling external resources in SPP.

Modeling Process
If a member acquires external resources outside their Model Area, the following modeling process should be followed:
1. All buses should be assigned numbers that are in the host’s Model Area bus number range.
2. Area Number/Name should be the host’s Model Area number.
3. Zone Number/Name should be in the host’s Model Area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Owner Data and Line Mileage Data (SSAE Control)

To meet the SSAE requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore; it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:
1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic...
messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. Area Interchange
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. Tie Line Metering
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. Area Totals
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. Network
   Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. Review of Output
   The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. Three useful reports for locating problems include:
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.
a. **Voltage Summaries**

Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.
The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. \( QT \) --- MAX = one-half of MW rating

ii. \( QB \) --- MIN = negative one-third of MW rating

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc…) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure in Section 5 to update MOD.
2. Submitting a PTI IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in “free format” with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data
for that bus will be removed (e.g., branches, transformers, generators, and loads). The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified. Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have “Area interchange control” with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of TCUL transformers with more than 50 tap steps shall be corrected.
6. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
7. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**Steady-State Modeling Requirements**

**GENERATORS**

1. All steady-state generators, including synchronous condensers and Static VAR Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the
step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the XSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

4. In accordance with PTI PSS®E requirements, the ZSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

**XSOURCE Table:**

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS FOR XSOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous:</td>
<td>Unsaturated sub-transient reactance ( (X''_d) ) [PU]</td>
</tr>
<tr>
<td>Detailed</td>
<td></td>
</tr>
<tr>
<td>Subtransient</td>
<td></td>
</tr>
<tr>
<td>Synchronous:</td>
<td>Unsaturated transient reactance ( (X'_d) ) [PU]</td>
</tr>
<tr>
<td>Non-Detailed</td>
<td></td>
</tr>
<tr>
<td>Classical or Transient</td>
<td></td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated transient reactance ( (X'_d) ) of single machine</td>
</tr>
<tr>
<td>Wind Type 1</td>
<td>[PU]</td>
</tr>
<tr>
<td>Wind Type 2</td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>Locked rotor reactance (sum of rotor and stator leakage reactances) [PU]</td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated transient reactance ( (X'_d) ) of single machine</td>
</tr>
<tr>
<td>Wind Type 3</td>
<td>[PU]</td>
</tr>
<tr>
<td>Renewable:</td>
<td>( V_{\text{rated}} = \text{Rated Voltage} = 1.0 \ [\text{PU}] ) (assumed)</td>
</tr>
<tr>
<td>Inverter-Based Solar PV</td>
<td>( I_{\text{rated}} = \text{Rated Current From GO} \ [\text{PU}] )</td>
</tr>
<tr>
<td>Wind Type 4</td>
<td>( X_{\text{Source}} = V_{\text{rated}} / I_{\text{rated}} \ [\text{PU}] )</td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated sub-transient reactance ( (X''_d) ) [PU]</td>
</tr>
<tr>
<td>Wind Type 5</td>
<td></td>
</tr>
<tr>
<td>Generator Type</td>
<td>Desired Parameters</td>
</tr>
<tr>
<td>RSource (ZR)</td>
<td></td>
</tr>
<tr>
<td>XSource (ZX)</td>
<td></td>
</tr>
</tbody>
</table>
5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation. If a user model representing particular SVC and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:

a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used.
b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation

c. Different development phases
   i. These representations should be combined as the phases are placed in service as applicable

OTHER DEVICES

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5, and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

   If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using \( R = 0.00000 + X = 0.0001 \) and \( B = 0.00000 \). These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold \( THRSHZ \) in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of \( R = 0.0001 + X = 0.002 \) and \( B = 0.00000 \). This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.
8. Transformers – To adequately model transformers, the following parameters, at a minimum, are required:

   a. **Nominal voltage of windings and bus reference to which the appropriate winding is connected**

      When entering transformer data, the rated voltage\(^{14}\) for all applicable windings should be specified. For non-LTC transformers, the winding voltage should be set to the tap voltage.

      A recommended approach is to model three-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 1
      - X, or Low-Voltage, Winding = Winding 2
      - Y, or Tertiary-Voltage, Winding = Winding 3

      A recommended approach is to model two-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 2
      - X, or Low-Voltage, Winding = Winding 1

      The two-winding\(^{15}\) transformer winding map is in this order by default since PSSE requires all two-winding transformers with Load Tap Changers (LTCs) to specify the tap bus as Winding 1. While not all LTC transformers have the tap on the X winding, this is common with most transformers.

   b. **Impedance(s)**

      A recommended approach to modeling transformer impedance is to set the winding MVA base to the system MVA base which is 100 MVA, entered as positive sequence data in pairwise (delta) format. Care should be taken to when entering transformer impedance data to ensure that the data entered corresponds to the appropriate base (system or winding).

      Enter zero sequence data in the format appropriate to the connection code.

      Connection codes <10:
      - The zero sequence data must be entered as T-model format

      Connection codes >10:
      - The zero sequence data must be entered in pairwise (delta) format

   c. **Tap ratios**

      Depending on the PSSE winding code used for the transformer, the setting should be either p.u. or kV. It should be noted, “tap ratio”, “winding ratio”, and “turns ratio” are synonymous.

\(^{14}\) Care should be taken to enter the rated voltage, which may be different than the nominal voltage of the system for all transformer windings. There can be a difference between the rated voltage of the system and the transformer (nominal).

\(^{15}\) Two winding representation in PSSE allows the user to select which bus number (from or to) the winding 1 resides.
• For transformers with no taps, use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
• For transformers with automatically adjusting, under-load tap changers (ULTC), it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
  o For parallel transformers, it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio for both transformers in order to prevent circulating VARs.
• For transformers with non-automatically adjusting, under-load tap changers (ULTC), it is recommended to use the tap ratio as set in the field.
• For transformers with no-load tap changers (NLTC), it is recommended to use the tap ratio as set in the field.
• It is recommended that Delta-Wye phase angle differences are incorporated appropriately in the models.

d. Minimum and maximum tap position limits
• Minimum and maximum tap position limits (RMIN and RMAX) shall be modeled based on transformer test report or manufacturer nameplate data control mode.

e. Number of tap positions (for both the ULTC and NLTC)
• Under-load tap changers (ULTC) control bus, total number of tap positions, and tap setting shall be specified.
• No-load tap changers (NLTC) total number of tap positions and the tap setting shall be specified.
• Transformer tap positions are discrete. The total number of transformer tap positions is a fixed quantity and shall be entered. The maximum and minimum transformer tap positions represent the physical boundaries of the transformer’s capability to modify its winding impedance to achieve a control objective. Transformer tap changing control modes may include voltage regulation, as well as real and reactive power control. Automatically-adjusting under-load tap changing transformers (ULTC) shall specify a control mode, the bus that is being controlled, and the control limits defined by the maximum and minimum transformer tap positions.
• For transformers with untapped windings, the number of tap positions shall be “99” to indicate that there are no taps. PSSE does not allow a value of “1” to be used as a tap position.

f. Regulated bus (for voltage regulating transformers)
• The regulated bus is the location where the transformer is regulating voltage. Typically this regulated bus is connected to a transformer winding bus.

16 It is noted that PSSE provides transformer tap changer limit fields called VMAX and VMIN, regardless of control mode. For example, if a real power control mode is selected, the user must enter MW quantities in the VMAX and VMIN fields.
• A limit difference of less than 0.0125 p.u. shall not be used when entering the regulated voltage band limits (VMAX, VMIN) for an automatically adjusting, under-load tap changers (ULTC) transformer.

• It is recommended that the voltage band limits VMAX and VMIN be no less than 0.025 p.u., to prevent toggling of the ULTC during simulation iterations.

g. In-service status

• In-service status, set to zero (0) if the device is not in-service.

c.h. Vector group and Connection code

• The vector group shall match the topological configuration of the buses representing where the windings are connected (e.g. A 115/69 kV load serving transformer with a vector group of Dyn11 must show the winding 1 bus [Delta winding] as the 115 kV bus).

• Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

• The transformer core construction should be considered (shell type or core type).

i. Transformers Controlling Reactive Power Flow

• The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.


18 Reference the TPL-007-1 Data Collection Template User Guide document under the Transformers section/Core Type. https://www.spp.org/spp-documents-filings/?id=197519
controlling voltage and the difference, in per unit, should be at least twice the tap step size. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

9. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes. PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:
   a. Real-time operational auto or manual adjustment operation of the PST.
   b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18 MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
   c. Real-time operational MW flow limits (e.g. ±20 MW).
   d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
   e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
   f. Applicable long-term firm transmission service levels for the PST.

11. Branch and Transformer Ratings – Normal is defined as continuous ratings for system intact conditions and emergency is defined as limited duration ratings used until the system is returned to normal. Accurate normal and emergency seasonal ratings of facilities are necessary to permit proper assessment of facility loading in regional and interregional studies. Three rating fields are provided for each branch and each transformer winding. Normal and emergency ratings should be entered in the first two fields (RATEA and RATEB, respectively); use of the third rating field (RATEC) is optional. Ratings should be omitted for model elements which are part of an electrical equivalent. The rating of a branch or transformer winding should not exceed the rating of the most limiting series element in the circuit, including terminal connections and associated equipment. The emergency rating should be greater than or equal to the normal rating.

12. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

13. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled
explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

14.13 Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

15.14 Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16.15 Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

17.16 Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

18.17 Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

19.18 Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

20.19 Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

21.20 Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

22.21 Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth
(difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

23.22 Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point, as well as any associated fixed-switched shunt equipment should also be modeled based on actual seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service status equal to zero. In-service Static Var Systems should be modeled with an in-service status equal to one.

24.23 DC Transmission systems – DC transmission systems must be represented with a sufficiently detailed model to simulate its expected behavior.

26. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it. (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)
2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.
3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during Equivalencing.
4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.
5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.
6. Unrealistic tap changing transformer tap limits.
7. Radial system is very large.
8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
b. Regulation of a radial line at both ends at unequal voltages.
c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
d. Conflicting voltage regulation.
e. Unreasonably small voltage range for switched shunts.
f. Remote regulation of more than one bus away.

10. Not solvable from flat start.
11. Fictitious regulation of buses.
12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.
14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.
15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area. While typically analogous to

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19 The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

20 Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\textsuperscript{21} loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

![Figure 1. Example of interconnected model areas.](image)

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\textsuperscript{21} ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (P\text{gen}) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as "transactions" and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:

---

Figure 2. Four types of inter-SPP pseudo-ties.
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).
b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

### Inter-area Bilateral transaction description

**Data Owner A exports MW to Data Owner B**

**Data Owner B imports MW from Data Owner A**

### Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 3. Example of Inter-area transfer (transaction).*
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where external resource is located to the generation owner control area. If the external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area’s number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

<table>
<thead>
<tr>
<th>No Transaction Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Area: XXX</td>
</tr>
<tr>
<td>Sink Area: YYY</td>
</tr>
<tr>
<td>Sink Load: XXX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transaction Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Area: XXX</td>
</tr>
<tr>
<td>Sink Area: YYY</td>
</tr>
<tr>
<td>Sink Load: YYY</td>
</tr>
</tbody>
</table>

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC's ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

AC Contingency Analysis

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPF reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the SPP RTO with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:
1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamic model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code

The schedule for submission of Dynamic data and list of MDWG Dynamic models (case types) can be found on the SPP corporate website, www.spp.org.

Dynamics Data Submittal Requirements and Guidelines

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit.
   The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.
   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.
   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers modeled in detail per Requirement II.1 shall also include representations of the generator, excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.

c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.

d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), Flexible AC Transmission System (FACTS), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

4.5. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

5.6. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

6.7. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

7.8. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

8.9. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

9.10. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross
compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

PROCEDURE FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES
Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   c. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   d. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or −9999.
   e. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      viii. Branches with extreme impedances or tap ratios [BRCH].
       Suggested options are:
       a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
       b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
       c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values
are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.

d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

f. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]

c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE]

e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)

a. Specify CONEC, CONET, and COMPILE files.

b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using “user dynamics”.

a. Read converted load flow [CASE].

b. Read in the dynamic data file [DYRE]
c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.

d. Check consistency of dynamic models [DYCH, option 1].

e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.

   i. Warning messages for

      a) Generators in the load flow for which there is no active machine model.
      b) Models, usually of excitation systems or governors, initialized out of limits.
      c) The number of iterations required to initialize the initial-conditions steady-state.

   ii. A tabulation of conditions at each online machine

      a) Terminal voltage
      b) Exciter output voltage
      c) Real and reactive power output
      d) Power factor
      e) Machine angle in degrees
      f) Direct and quadrature axis currents on machine base.

   iii. A diagnosis of initial conditions, either

      a) “Initial conditions check OK”, or
      b) A listing of suspect initial conditions generally states whose time derivative is not “small” (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.

   iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of

   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).
14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((-K) = (-1/R)\), mechanical power to \((1-1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Dynamic Data Format

**PSS®E Users**

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyre file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

**Non-PSS®E Users**

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, excitors, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

The PSS/E simulation software dynamic machine models may be used as long as they are included on the NERC List of Acceptable Models for Interconnection-Wide Modeling and not identified as unacceptable models on that list. NERC maintains a list of acceptable dynamic models on the NERC website for reference by the GO. Only NERC acceptable dynamic models from the latest approved list shall be provided to the applicable TPs and to SPP, as PC, for dynamic model building purposes. The NERC acceptable dynamic model list can be found on the NERC SAMS website. Significant improvements to models may occur over time and models may become obsolete, not recommended, or unacceptable models. Unsatisfactory models might still be available in the PSS/E software; however, those models must be replaced with more suitable current acceptable models.

**User-written dynamic models will only be allowed under the following conditions:**

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment from the Data Owner to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months
MDWG developed a subset list of acceptable dynamic models based on the NERC acceptable dynamic model list and adheres to the guidance outlined in the MDWG Dynamic Models Guidelines document.

Dynamic models that are considered unacceptable by NERC, shall be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

Dynamic model data must be in a Siemens PTI PSS®E standard library model format. User-written dynamic models will only be allowed under the following conditions:

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified by SPP.

Dynamics Data Validation Requirements

1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).
2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.
Procedures for Submission of Dynamics Data to the MMWG Coordinator

Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template

Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.

The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another model of the same equipment group</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes for new model.</td>
<td>1. A DC exciter is replaced by a static exciter. 2. A classical machine model is replaced by a detailed model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all models of an existing unit</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Change bus number</td>
<td>No</td>
<td>No</td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
</tr>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
<td>Same requirements whether unit is at new or existing bus.</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Complete Set of Dynamics Data

The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

System Dynamic Data Base and Dynamic Simulation Cases
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

1. The Short Circuit data listed in Attachment 1 of the NERC Standard MOD-032-1 located on the NERC website.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators the positive and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Mutual Impedance

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line.
Zero-sequence current is only present during ground faults, so the consideration of mutual coupling effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence fault current. It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.22

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSSE, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSSE models can be identified by checking when mutual impedance data is modeled and updated in a company’s primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

**Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).** The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the MDWG Powerflow models. **All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint.** The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

22 NERC Lesson Learned: Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements
All transformers shall have a Vector Group and corresponding Connection Code in PSSE 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of the modeled sequence information prior to finalization.

Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.
SECTION 6: DEFINITIONS

These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner** 23 – The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Data Submitter** 4 – The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered a power export and a negative value is considered a power import.

---

23 Not a NERC functional entity
Model Area – The collection of model objects comprising an entity's network and uniquely numbered in PSS®E.

Peak Demand – The highest demand including transmission losses for energy measured over a one clock hour period.\textsuperscript{24}

PSS®E – Siemens PTI's Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

PSS®E MOD – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

PSS®MOD File Builder – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS®MOD Modeling projects by comparing PSS®E models.

Transaction (Model) – A modeled purchase and/or sale of power.

Non-scalable load – Load that does not conform to the daily load duration curve.

On-Peak (Model) – Those hours or other periods typically considered periods of higher electrical demand.

Off-Peak (Model) – Those hours or other periods typically considered periods of lower electrical demand.

Regulating device – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

Shortfall – Occurs when an entity does not have enough dispatchable generation to serve the entity's load.

Tie Line (Model) – A circuit connecting two Model Areas.

\textsuperscript{24} Attachment AA Resource Adequacy Section 2
SECTION 7: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,
From Area Name,
From Bus#,
From Bus Name,
From Bus kV,
To Region Name,
To Area#,
To Area Name,
To Bus#,
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI (pu),
BI (pu),
GJ (pu),
BJ (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
Ckt,
Cw,
Cz,
Cm,
Mag1,
Mag2,
Metered Side,
Name,
Status (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT 1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM11,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#, Winding 1 Area Name,
Winding 1 Bus#, Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#, Winding 2 Area Name,
Winding 2 Bus#, Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#, Winding 3 Area Name,
Winding 3 Bus#, Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMTR(1,2,3),
NAME,
STATUS(0,1),
Owner 1, Fraction 1,
Owner 2, Fraction 2,
Owner 3, Fraction 3,
Owner 4, Fraction 4,
R1-2, X1-2,
SBase1-2, R2-3, X2-3,
SBase2-3, R3-1,
Three Winding Transformer Data Fields - continued
X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus #(CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RM11,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued

RM12,
VMA2,
VM12,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RM3,
VMA3,
VM3,
NTP3,
TAB3,
CR3,
CX3
**Two Terminal DC Tie Data Fields**

- In Service Date,
- Out Service Date,
- I,
- MDC,
- RDC,
- SETVL,
- VSCHD,
- VCMOD (1,0),
- RCOMP,
- DELTI,
- METER (R,I),
- DCVMIN,
- CCCITMX,
- CCCACC,
- IPR REGION NAME,
- IPR AREA#,
- IPR AREA NAME,
- IPR Bus#,  
- IPR BUS NAME,
- IPR BUS kV,
- NBR,
- ALFMX,
- ALFMN,
- RCR,
- XCR,
- EBASR,
- TRR,
- TAPR,
- TMXR,
- TMNR,
- STPR,
- ICR REGION NAME,
- ICR AREA#,
- ICR AREA NAME,
- ICR BUS#,  
- ICR BUS NAME,
- ICR BUS kV,
- IFR REGION NAME,
- IFR AREA#,
- IFR AREA NAME,
- IFR BUS#,  
- IFR BUS NAME,
- IFR BUS kV,
- ITR REGION NAME,
- ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS #,
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAPR,
IPI REGION NAME,
IPI AREA #,
IPI AREA NAME,
IPI Bus #,
IPI BUS NAME,
IPI BUS KV,
NBI,
GAMMX,
GAMMN,
RCI,
XCI,
EBASI,
TRI,
TAPI,
TMXI,
TMNI,
STPI,
ICI REGION NAME,
ICI AREA #,
ICI AREA NAME,
ICI BUS #,
ICI BUS NAME,
ICI BUS KV,
IFI REGION NAME,
IFI AREA #,
IFI AREA NAME,
IFI BUS #,
IFI BUS NAME,
IFI BUS KV,
ITI REGION NAME,
ITI AREA #,
ITI AREA NAME,
ITI BUS #,
ITI BUS NAME,
ITI BUS KV,
IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
## SECTION 8: APPENDIX II
### UTILIZED IMPEDANCE CORRECTION TABLES

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<thead>
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<th>Table Number</th>
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<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
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SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice

Designating MOD-032-1 Data Submittal Assignment

On this _______ day of ______________, 20______, _______________________ and __________________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following:

On ___________________, 20____, _____________________, Data Owner, and _______ __________________, Data Submitter, entered into an agreement through which _________________________ has agreed to submit on behalf of ___________________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

__________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________

The accuracy of the data is the responsibility of the Data Owner. This notice does not shift the compliance obligation from the Data Owner to the data submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER: SPP hereby acknowledges receipt of this notice.

By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: _______________

On behalf of DATA SUBMITTER:

By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: _______________
## SECTION 10: APPENDIX IV SPP MODEL ON DEMAND (MOD) MATRIX

<table>
<thead>
<tr>
<th>SPP MOD Project Type/Status Matrix</th>
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<tr>
<td><strong>Type</strong></td>
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<tr>
<td>---</td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
</tr>
<tr>
<td>Attachment AQ</td>
</tr>
<tr>
<td>Generation Interconnection</td>
</tr>
<tr>
<td>Network Status</td>
</tr>
<tr>
<td>Modeling Correction</td>
</tr>
<tr>
<td>System Impact Allocation</td>
</tr>
</tbody>
</table>
The table below indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state (Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)</th>
<th>dynamics (If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td>a. Positive Sequence Data</td>
<td>a. Positive Sequence Data</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td>b. Negative Sequence Data</td>
<td>b. Negative Sequence Data</td>
</tr>
<tr>
<td>2. Aggregate Demand²⁵ [LSE]</td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>c. Zero Sequence Data</td>
</tr>
<tr>
<td>a. real and reactive power¹</td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>2. Mutual Line Impedance Data [TO]</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td>4. Power System Stabilizer [GO, RP (for future planned resources only)]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>3. Generating Units²⁶ [GO, RP (for future planned resources only)]</td>
<td>5. Demand [LSE]</td>
<td></td>
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<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td>6. Wind Turbine Data [GO]</td>
<td></td>
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<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td>7. Photovoltaic systems [GO]</td>
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<tr>
<td>c. station service auxiliary load for normal plant configuration (provide)</td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
<td></td>
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<td></td>
<td>9. DC system models [TO]</td>
<td></td>
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<td></td>
<td>10. Other information requested by the Planning Coordinator or</td>
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</tbody>
</table>

²⁵ For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

² For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

³ Including synchronous condensers and pumped storage.
<p>| | |</p>
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<tr>
<td><strong>data in the same manner as that required for aggregate Demand under item 2, above</strong></td>
<td><strong>Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</strong></td>
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<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
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</tr>
<tr>
<td>e. machine MVA base</td>
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</tr>
<tr>
<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
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</tr>
<tr>
<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
<td></td>
</tr>
<tr>
<td>h. in-service status*</td>
<td></td>
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<tr>
<td><strong>4. AC Transmission Line or Circuit [TO]</strong></td>
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<tr>
<td>a. impedance parameters (positive sequence)</td>
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</tr>
<tr>
<td>b. susceptance (line charging)</td>
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<tr>
<td>c. ratings (normal and emergency)*</td>
<td></td>
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<tr>
<td>d. in-service status*</td>
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<tr>
<td><strong>5. DC Transmission systems [TO]</strong></td>
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<tr>
<td><strong>6. Transformer (voltage and phase-shifting) [TO]</strong></td>
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</tr>
<tr>
<td>a. nominal voltages of windings</td>
<td></td>
</tr>
<tr>
<td>b. impedance(s)</td>
<td></td>
</tr>
<tr>
<td>c. tap ratios (voltage or phase angle)*</td>
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</tr>
<tr>
<td>d. minimum and maximum tap position limits</td>
<td></td>
</tr>
<tr>
<td>e. number of tap positions for both the ULTC and NLTC</td>
<td></td>
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<tr>
<td>f. regulated bus (for voltage regulating transformers)*</td>
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</tr>
<tr>
<td>g. ratings (normal and emergency)*</td>
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<tr>
<td>h. in-service status*</td>
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</table>
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GD, LSE, TO, TSP]
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
September 12th, 2019
Conference Call
A G E N D A
9:00 a.m. – 12:00 p.m. (CDT)

1. Administrative Items ................................................................. Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
   f. Previous Meeting Minutes
      i. August 8th, 2019 (Approval Item)
   g. Action Items Review

2. 2019 MDWG Model Series
   a. MDWG Dynamics Model Build Update .................................. Sunny Raheem (5 mins)

3. 2020 MDWG Model Series
   a. Power Flow Model Build Update ....................................... Lottie Richardson (20 mins)
   b. Short Circuit Model Build Update ........................................ Michael Odom (5 mins)
   c. Dynamic Model Build Schedule Development Preview ...... Sunny Raheem (5 mins)

4. MDWG Focus Group Updates
   a. Dynamics ................................................................. Marc Moor/Sunny Raheem (10 mins)
   b. Power Flow ............................................................. Jerad Ethridge/Jeremy Harris (10 mins)
   c. Short Circuit ......................................................... Reené Miranda/Michael Odom (10 mins)

5. MDWG Manual Generator Language Update (Approval Item*) ................ Michael Odom (15 mins)

6. Break ......................................................................................................................................... (10 mins)

7. MDWG Charter/Scope Approval (Approval Item) ...................................... Sunny Raheem (15 mins)

8. Joint SPC/MOPC Briefing HITT Initiatives .............................................. Casey Cathey (45 mins)

9. ITP Quarterly Report Card ............................................................... Casey Cathey (15 mins)

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
11. Administrative Items

a. Summary of Action Items
b. Future Meetings (Central Time)
i. MDWG
   1. Next Conference Call: 2019 series MDWG Dynamic Model approval call on September 18th (9:00am – 11:00am)
   2. Next Face-to-Face: Xcel Office, Denver, CO October 22-23rd
ii. Manual Task Force:
   1. Weekly on Thursday 9am-11am
iii. Focus Groups Meetings:
   1. Power Flow: September 16th (9:30am –11:30am)
   2. Dynamics: October 9th (9:30am –11:30am)
   3. Short Circuit: November TBD (Joint with Power Flow)
c. Adjourn

Note: The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG.
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, Data Owners, equipment, and Data Submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1)1, and the provisions of the

1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

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\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

A completed Letter of Notice identifying responsibilities between a Data Owner and a Data Submitter is required to be submitted to SPP. This Letter of Notice is included in the appendix section.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner.4 When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the BES.
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to deliver that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.

5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement.
7 Sixth Revised Volume No.1, Attachment Al, Part II-1.
8 Sixth Revised Volume No.1, Attachment Al, Part II-2.
9 Sixth Revised Volume No.1, Part III-30.
10 Sixth Revised Volume No.1, Part III-31.
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

Accountability

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and DataSubmitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes.** In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models.
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

**Data Transmittal**

Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- **GlobalScape**
2. **E-MAIL** --- **SPPEngineeringModeling@spp.org**

The preferred method of submittal is through the "SPP MDWG File Sharing Site", GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP Model Release Guidelines**

**Steady-State and Short Circuit Models**

SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables
Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   Initialized steady state and regional contingency cases.
   a. Steady-State RAWD case file
   b. Conversion IDEV files

2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP’s GlobalScape under Modeling (CEII, RSD) → SPP Modeling Contacts → 3. Final Modeling Contacts

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

Compliance

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, long name, and associated Auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts that meet TPL-001 requirements shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be not Coincident to the SPP region, meaning that the hour that a Data Submitter's system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter's load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such
location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have an updated service agreement, or are in the process of finalizing a service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS®E idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter's load forecast data comprisal:

1. Not Coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

On-Peak/Off-Peak Models
Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority Coincident Peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td></td>
<td>Typically 70% - 80% of Summer On-Peak load level</td>
</tr>
</tbody>
</table>

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.
**Load Data**

Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID “R1”). These loads should be maintained in the Load Mapping worksheet of the EDST.

**Area Summary Report**

The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**

Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**

Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The "from bus," “to bus”, and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.
3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional.

6. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

7. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).
NOTE: When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

<table>
<thead>
<tr>
<th>Voltage Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Below 69 kV</td>
</tr>
<tr>
<td>2 - 69 kV</td>
</tr>
<tr>
<td>3 - 115 kV</td>
</tr>
<tr>
<td>4 - 138 kV</td>
</tr>
<tr>
<td>5 - 161 kV</td>
</tr>
<tr>
<td>6 - 230 kV</td>
</tr>
<tr>
<td>7 - 345 kV</td>
</tr>
<tr>
<td>8 - 500 kV</td>
</tr>
<tr>
<td>9 - 765 kV or above</td>
</tr>
</tbody>
</table>

1. For generator regulated buses, a desired voltage set point will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the Station Service or Auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Reactive reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.
Generator Data

Generating unit MW and MVAR output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per capability testing requirements in MOD-025-2 and SPP Planning Criteria 7.1.1. Generator real power rated capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with appropriate Auxiliary load modeled explicitly. Generator rated reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit testing data and set appropriate to the modeled MW dispatch amount (PGEN). Energy storage (e.g., pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (PGEN) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour.

For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to ZSOURCE Table.

For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

For generating units with small X/R ratios (such as small, renewable units) the armature resistance (Ra) must be included in the generator model and, therefore, a resistive component of ZSOURCE must be greater than zero. However, if a synchronous unit has a sufficiently large X/R ratio, the value of ZR may be neglected, leading to the observations that:

- Synchronous impedance (Zd) is equivalent to synchronous reactance (Xd)
- Transient impedance (Zd') is equivalent to transient reactance (Xd')
- Subtransient impedance (Zd'') is equivalent to subtransient reactance (Xd'')

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance information is provided.

When modeling mothballed and future retired units, the unit will be modeled offline (in-service status = 0) similar to units that are not dispatched in the particular seasonal model. Unit retirement information will be provided in a separate document and posted through a secure website. Decommissioned units should be removed from the models.

Modeling of Generator Parameters

5. Applicable Facilities - The following generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT:
   a. All Individual units greater than 20 MVA (gross nameplate rating)
b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

Generator Data
Generating unit MW and MVAR output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits with consideration of MOD-025-2 and SPP Planning Criteria 7.1.1. Check Generator MW and Mvar output to ensure the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits per testing requirements in SPP Planning Criteria 7.1.1 and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability of the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with Auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities.

For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to XSOURCE Table.

For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour. Ensure accurate values of ZR and ZX. This data is not needed in normal steady-state and equivalent construction work, but is required for switching studies, fault analysis and dynamic simulation. For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. The MDWG steady-state models will use the saturated subtransient impedance data for generators (X''di). Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance...
When modeling mothballed and future retired units, the unit will be modeled offline (in-service status = 0) similar to units that are not dispatched in the particular seasonal model. Unit retirement information will be provided in a separate document and posted through a secure website. Decommissioned units should be removed from the models.

**Modeling of Generator Parameters**

1. Applicable Facilities - The following Generators and SVCs connected to BES (100 kV and greater) or in accordance with the SPP OATT or Member OATT:
   a. All Individual units greater than 20 MVA (gross nameplate rating)
   b. All Synchronous Condensers greater than 20 MVA (gross nameplate rating)
   c. Generating plant/facilities greater than 75 MVA (gross aggregate nameplate rating)

**Modeling Process for Generator Parameters**

a. The Generator parameter \( P_{\text{MAX}} \) shall be modeled as a gross seasonal maximum capability based on SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.

b. Generating plant Station Service load and Auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All Station Service load and Auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus\(^{11}\), corresponding to the voltage to which the Auxiliary load is served. Model representations of Auxiliary load connected to the generating unit bus (Figure VII-1), Auxiliary load modeled with separate transformation (Figure VII-2), and Auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

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11 Station Service load and Auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant Auxiliary load.
Experience has shown that generating plant Station Service load and Auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant Station Service load and Auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable Station Service load and Auxiliary load.

If generating plant Station Service load and Auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant Station Service load and Auxiliary load shall use “Sn” in the Load ID for one or more aggregated generating plant Station Service loads (Figure VII-4a).

If generating plant Station Service load and Auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant Station Service load and Auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “Fn” in the Load ID field to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “Vn” in the Load ID field to designate variable load quantities that do vary with plant dispatch.

**Figure VII-4. Examples of generating plant Auxiliary load representations (aggregated, combined, and discrete).**

Only generating plant Station Service load or Auxiliary load IDs should be labeled with “Sn”, “Fn”, or “Vn” all other load types should be labeled differently.

Generating plant Station Service load or Auxiliary load IDs of “Sn” or “Vn” should be modeled such that the in-service status of the load follows the in-service status of the generator in which it is.

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12 “n” represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
connected. For example: Generator 1 is offline, then the associated generating plant Station Service load or Auxiliary load with load IDs of "Sn" or "Vn" should also be offline.

d. The Generator Parameters for PMIN, AUX Load, QMAX, and QMIN shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

**Modeling of Wind/Solar Renewable Resources \( P_{\text{GEN}} \)**

- **Spring Light Load Off-Peak models:** Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility's latest five-year average (or replacement data if unavailable) for the SPP minimum load hour corresponding to the season of the Light Load case, not to exceed each facility's firm service amount. The methodology used to calculate replacement data is described in the ITP Manual. Solar resources will be modeled at zero MW output in the light load case regardless of the facility's long-term firm transmission service amount.

- **On-Peak & Summer Shoulder Off-Peak models:** Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility's latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident\(^{13}\) peak, not to exceed each facility's firm service amount.

- **SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build.** Any renewable resource modeling data submitted to the PC, after the initial dispatch list is provided, will be dispatched at the seasonal state dispatch percentage of the renewable resource's nameplate amount.

- **When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount.** If agreement cannot be reached, the case can be brought to the MDWG for a decision.

- **Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.**

- **For resources that do not have firm service, \( P_{\text{GEN}} \) values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases.** If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

**Data Exemption Process**

MDWG Members requested that there be a process by which the modeled generator maximum is different from the MOD-025-02/SPP Planning Criteria testing. In accordance with Attachment 1, Section 5 of MOD-025-02 an exception process for generators that have undergone testing per MOD-025-02/SPP Planning Criteria 7.1 for these differences is as follows:

1. Member will fill out the “Exemption Form” and send it via e-mail to “Engineering Modeling” containing:

\(^{13}\) SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
Shortfall Guidance Process
Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.
2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements:
   e. The in-service date shall be based on the expected in-service date of the GI study.
   f. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).
   g. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
3. Future Exploratory Generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future Exploratory Generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, Exploratory Generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of Exploratory Generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

External Resource Modeling
Purpose
This procedure assures that members adhere to a uniform process when modeling external resources in SPP.

Modeling Process
If a member acquires external resources outside their Model Area, the following modeling process should be followed:

1. All buses should be assigned numbers that are in the host’s Model Area bus number range.
2. Area Number/Name should be the host’s Model Area number.
3. Zone Number/Name should be in the host’s Model Area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

**Owner Data and Line Mileage Data (SSAE Control)**

To meet the [Statement on Standards for Attestation Engagement (SSAE)](https://www.ssaeglobal.com/) requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore; it is important that Members keep the data current in MOD.

The [MMWG Procedure Manual](https://www.ssaeglobal.com/) contains information related to the following:

1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

**Initial Run Review**

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should
also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**
   Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

   Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

   The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum...
number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. Summary of Overloaded Branches
This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. Generation Summary
All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, MVAR ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. QT --- MAX = one-half of MW rating
ii. QB --- MIN = negative one-third of MW rating

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated
equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).

Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)
Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)

Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure to update MOD.
2. Submitting a PTI, IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation
The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

**PTI-PSS®E Data Format**

Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a **comma** (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is **added** to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The **modification** of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data for that bus will be removed (e.g., branches, transformers, generators, and loads). **The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified.** Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have "Area interchange control" with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with \(VHI - VLO < .005\) per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
6. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.
Steady-State Modeling Requirements

**GENERATORS**

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.

2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the XSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

**XSOURCE Table:**

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS FOR XSOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous:</td>
<td>Unsaturated sub-transient reactance ($X''_d$) [PU]</td>
</tr>
<tr>
<td>Detailed</td>
<td></td>
</tr>
<tr>
<td>Subtransient</td>
<td></td>
</tr>
<tr>
<td>Synchronous:</td>
<td>Unsaturated transient reactance ($X'_{ad}$) [PU]</td>
</tr>
<tr>
<td>Non-Detailed</td>
<td></td>
</tr>
<tr>
<td>Classical or</td>
<td></td>
</tr>
<tr>
<td>Transient</td>
<td></td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated transient reactance ($X'_{ad}$) of single</td>
</tr>
<tr>
<td>Wind Type 1</td>
<td>machine [PU*]</td>
</tr>
<tr>
<td>Wind Type 2</td>
<td>OR</td>
</tr>
</tbody>
</table>
Locked rotor reactance (sum of rotor and stator leakage reactances) [PU]

Renewable: Wind Type 3
- Unsaturated transient reactance ($X'_d$) of single machine [PU]

Renewable: Inverter-Based Solar PV Wind Type 4
- $V_{\text{rated}} = \text{Rated Voltage} = 1.0$ [PU] (assumed)
- $I_{\text{rated}} = \text{Rated Current From GO}$ [PU]
- $X_{\text{Source}} = \frac{V_{\text{rated}}}{I_{\text{rated}}}$ [PU]

Renewable: Wind Type 5
- Unsaturated sub-transient reactance ($X''_d$) [PU]

* PU values should be based on the rated terminal voltage and machine MVA base

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation. If a user model representing particular SVC and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:

a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used
b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation
c. Different development phases
   i. These representations should be combined as the phases are placed in service as applicable

OTHER DEVICES

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.
2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines,
Reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity. If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to "load net" (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using $R=0.00000 + X=0.0001$ and $B=0.00000$. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold $THRSHZ$ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of $R=0.0001 + X=0.002$ and $B=0.00000$. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – To adequately model transformers, the following parameters, at a minimum, are required:
   a. Nominal voltage of windings and bus reference to which the appropriate winding is connected

   When entering transformer data, the rated voltage for all applicable windings should be specified. For non-LTC transformers, the winding voltage should be set to the tap voltage.

   A recommended approach is to model three-winding transformers such that the winding buses map to the transformer windings as follows:
   - $H$, or High-Voltage, Winding = Winding 1
   - $X$, or Low-Voltage, Winding = Winding 2

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14 Care should be taken to enter the rated voltage, which may be different than the nominal voltage of the system for all transformer windings. There can be a difference between the rated voltage of the system and the transformer (nominal).
A recommended approach is to model two-winding transformers such that the winding buses map to the transformer windings as follows:
- Y, or Tertiary-Voltage, Winding = Winding 3
- H, or High-Voltage, Winding = Winding 2
- X, or Low-Voltage, Winding = Winding 1

The two-winding transformer winding map is in this order by default since PSS®E requires all two-winding transformers with Load Tap Changers (LTCs) to specify the tap bus as Winding 1. While not all LTC transformers have the tap on the X winding, this is common with most transformers.

b. Impedance(s)

A recommended approach to modeling transformer impedance is to set the winding MVA base to the system MVA base which is 100 MVA, entered as positive sequence data in pairwise (delta) format. Care should be taken when entering transformer impedance data to ensure that the data entered corresponds to the appropriate base (system or winding).

Enter zero sequence data in the format appropriate to the connection code.

Connection codes <10:
- The zero sequence data must be entered as T-model format
Connection codes >10:
- The zero sequence data must be entered in pairwise (delta) format

c. Tap ratios

Depending on the PSS®E winding code used for the transformer, the setting should be either p.u. or kV. It should be noted, “tap ratio”, “winding ratio”, and “turns ratio” are synonymous.

- For transformers with no taps, use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
- For transformers with automatically adjusting, under-load tap changers (ULTC), it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
  - For parallel transformers, it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio for both transformers in order to prevent circulating VARs.
- For transformers with non-automatically adjusting, under-load tap changers (ULTC), it is recommended to use the tap ratio as set in the field.
- For transformers with no-load tap changers (NLTC), it is recommended to use the tap ratio as set in the field.
- It is recommended that Delta-Wye phase angle differences are incorporated appropriately in the models.

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15 Two winding representation in PSS®E allows the user to select which bus number (from or to) the winding 1 resides.
d. Minimum and maximum tap position limits
   • Minimum and maximum tap position limits (RMIN and RMAX) shall be modeled based on transformer test report or manufacturer nameplate data.

e. Number of tap positions (for both the ULTC and NLTC)
   • Under-load tap changers (ULTC) control bus, total number of tap positions, and tap setting shall be specified.
   • No-load tap changers (NLTC) total number of tap positions and the tap setting shall be specified.
   • Transformer tap positions are discrete. The total number of transformer tap positions is a fixed quantity and shall be entered. The maximum and minimum transformer tap positions represent the physical boundaries of the transformer’s capability to modify its winding impedance to achieve a control objective. Transformer tap changing control modes may include voltage regulation, as well as real and reactive power control. Automatically-adjusting under-load tap changing transformers (ULTC) shall specify a control mode, the bus that is being controlled, and the control limits \[^{16}\] defined by the maximum and minimum transformer tap positions.
   • For transformers with untapped windings, the number of tap positions shall be “99” to indicate that there are no taps. PSS®E does not allow a value of “1” to be used as a tap position.

f. Regulated bus (for voltage regulating transformers)
   • The regulated bus is the location where the transformer is regulating voltage. Typically this regulated bus is connected to a transformer winding bus.
   • A limit difference of less than 0.0125 p.u. shall not be used when entering the regulated voltage band limits (VMAX, VMIN) for an automatically adjusting, under-load tap changers (ULTC) transformer.
   • It is recommended that the voltage band limits VMAX and VMIN be no less than 0.025 p.u., to prevent toggling of the ULTC during simulation iterations.

g. In-service status
   • In-service status, set to zero (0) if the device is not in-service.

h. Vector group and Connection code
   • The vector group shall match the topological configuration of the buses representing where the windings are connected (e.g. A 115/69 kV load serving transformer with a vector group of Dyn11 must show the winding 1 bus [Delta winding] as the 115 kV bus).
   • Transformer connection codes \[^{17}\] and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates

\[^{16}\] It is noted that PSS®E provides transformer tap changer limit fields called VMAX and VMIN, regardless of control mode. For example, if a real power control mode is selected, the user must enter MW quantities in the VMAX and VMIN fields.

concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.

- The transformer core construction should be considered (shell type or core type).

i. Transformers Controlling Reactive Power Flow
   - The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.

9. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes.
    PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:
    a. Real-time operational auto or manual adjustment operation of the PST.
    b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
    c. Real-time operational MW flow limits (e.g. ±20 MW).
    d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
    e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
    f. Applicable long-term firm transmission service levels for the PST.

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18 Reference the TPL-007-1 Data Collection Template User Guide document under the Transformers section/Core Type. https://www.spp.org/spp-documents-filings/?id=197519
11. **AC transmission line or circuit modeling status** – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

12. **Generator Step-Up Transformers (GSU)** – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

13. **Generator modeling status** – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

14. **Generator MW Limits** – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

15. **Generator MVAR Limits** – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. **Small Generators, Capacitors, and Static VAR Devices** – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

17. **Coordination of Regulating Devices** – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

18. **Over and Under Voltage Regulation** – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

19. **Flowgates** – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.
20. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

21. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

22. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service status equal to zero. In-service Static Var Systems should be modeled with an in-service status equal to one.

23. DC Transmission systems – DC transmission systems must be represented with a sufficiently detailed model to simulate its expected behavior.

24. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

25. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it.
   (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during Equivalencing.
4. A system's regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. Fictitious regulation of buses.

12. Extremely low voltage schedules.

13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
**Troubleshooting**

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the “From” bus and the second-named bus is taken as the “To” bus. The “From” bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

**Note:** The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

**Balancing and Transactions**

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area. While typically analogous to a

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19 The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

20 Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\(^{21}\) loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

![Example of interconnected model areas.](image)

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

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\(^{21}\) ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (Pgen) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

![Inter-area Bilateral transaction description]

Data Owner A exports MW to Data Owner B
Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

Figure 3. Example of Inter-area transfer (transaction).
Intra-area Bilateral transaction description
Data Owner A exports MW to Data Owner C
Data Owner C imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>XZ112</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>XZ112</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

Figure 4. Example of Intra-area transfer (transaction).

6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where external resource is located to the generation owner control area. If the external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area's number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

No Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC's ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPP reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the SPP RTO with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:

1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamic model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code

The schedule for submission of Dynamic data and list of MDWG Dynamic models (case types) can be found on the SPP corporate website, www.spp.org.

Dynamics Data Submittal Requirements and Guidelines

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.
The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.
The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers shall also include representations of the generator, excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.

d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), Flexible AC Transmission System (FACTS), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

6. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:

a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and

b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

7. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

8. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

9. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

10. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

11. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.
Procedure for Initialization and No-Disturbance Checks Of Library Dynamics Cases

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or –9999.
   c. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      viii. Branches with extreme impedances or tap ratios [BRCH]. Suggested options are:
         a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
         b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
         c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.
         d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.
         e) High tap ratios.
         f) Low tap ratios.
   d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit "carriage return" for no change.
i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]

c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].

e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case.[SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)

a. Specify CONEC, CONET, and COMPILE files.

b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using “user dynamics”.

a. Read converted load flow [CASE].

b. Read in the dynamic data file [DYRE]

c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.

d. Check consistency of dynamic models [DYCH, option 1].

e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.

i. Warning messages for

a) Generators in the load flow for which there is no active machine model.

b) Models, usually of excitation systems or governors, initialized out of limits.

c) The number of iterations required to initialize the initial-conditions steady-state.
ii. A tabulation of conditions at each online machine
   a) Terminal voltage
   b) Exciter output voltage
   c) Real and reactive power output
   d) Power factor
   e) Machine angle in degrees
   f) Direct and quadrature axis currents on machine base.

iii. A diagnosis of initial conditions, either
   a) “Initial conditions check OK”, or
   b) A listing of suspect initial conditions generally states whose time derivative is not
      “small” (relative to the value of the state). These may be caused by inconsistencies
      between the real and reactive power scheduled for a unit by the load flow
      (including automatic changes in reactive power to hold bus voltage at a target
      level) or by parameter errors.

   iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((-K) = (-1 / R)\), mechanical power to \((1-1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.
**Dynamic Data Format**

**PSS®E Users**
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyr file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

**Non-PSS®E Users**
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

**Acceptable Dynamic Model Information**
The PSS®E simulation software dynamic machine models may be used as long as they are included on the NERC List of Acceptable Models for Interconnection-Wide Modeling and not identified as unacceptable models on that list. The NERC acceptable dynamic model list can be found on the NERC SAMS website ➔ SAMS Reference Materials ➔ NERC Acceptable Model List.

Significant improvements to models may occur over time and models may become obsolete, not recommended, or unacceptable models. Unacceptable models might still be available in the PSS®E software; however, those models must be replaced with more suitable current acceptable models.

User-written dynamic models will only be allowed under the following conditions:
1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes.
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment from the Data Owner to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified of request for conversion to an acceptable model by SPP or Transmission Planner.

MDWG developed a subset list of acceptable dynamic models based on the NERC acceptable dynamic model list and adheres to the guidance outlined in the MDWG Dynamic Models Guidelines document.

**Dynamics Data Validation Requirements**
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each
dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines
1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).

2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator
Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template
Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready. The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another model of the same equipment group</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes for new model.</td>
<td>1. A DC exciter is replaced by a static exciter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. A classical machine model is replaced by a detailed model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>models of an existing unit</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Change bus number</td>
<td>No</td>
<td>No</td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
</tr>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
<td>Same requirements whether unit is at new or existing bus.</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

**Complete Set of Dynamics Data**
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators the positive and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Mutual Impedance

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line. Zero-sequence current is only present during ground faults, so the consideration of mutual coupling effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence
fault current. It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.22

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSS®E, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSS®E models can be identified by checking when mutual impedance data is modeled and updated in a company’s primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

**Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).** The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the MDWG Powerflow models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company's RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

All transformers shall have a Vector Group and corresponding Connection Code in PSS®E 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary

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22 NERC Lesson Learned: Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements
analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of the modeled sequence information prior to finalization.

Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.
These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner** – The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Data Submitter** – The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered is a power export and a negative value is considered a power import.

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23 Not a NERC functional entity
**Model Area** – The collection of model objects comprising an entity’s network and uniquely numbered in PSS®E.

**Peak Demand** – The highest demand including transmission losses for energy measured over a one clock hour period.24

**PSS®E** – Siemens PTI’s Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

**PSS®E MOD** – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

**PSS®MOD File Builder** – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS®MOD Modeling projects by comparing PSS®E models.

**Transaction (Model)** – A modeled purchase and/or sale of power.

**Non-scalable load** – Load that does not conform to the daily load duration curve.

**On-Peak (Model)** – Those hours or other periods typically considered periods of higher electrical demand.

**Off-Peak (Model)** – Those hours or other periods typically considered periods of lower electrical demand.

**Regulating device** – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

**Shortfall** – Occurs when an entity does not have enough dispatchable generation to serve the entity’s load.

**Tie Line (Model)** – A circuit connecting two Model Areas.

24 Attachment AA Resource Adequacy Section 2
SECTION 7: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,  
From Area Name,
From Bus#, 
From Bus Name,
From Bus kV, 
To Region Name,  
To Area#, 
To Area Name,  
To Bus#,  
To Bus Name,  
To Bus kV, 
Metered End (F,T),  
CKT,  
R,  
X,  
B,  
Summer Rating A,  
Summer Rating B,  
Summer Rating C,  
Winter Rating A,  
Winter Rating B,  
Winter Rating C,  
GI (pu),  
BI (pu),  
GJ (pu),  
BJ (pu),  
STATUS (0,1),  
LEN (mi),  
Owner 1,  
Fraction 1,  
Owner 2,  
Fraction 2,  
Owner 3,  
Fraction 3,  
Owner 4,  
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
  COD1,
  Volt Control Bus Region Name,
  Volt Control Bus Area Number,
  Volt Control Bus Area Name,
  Volt Control Bus Number (CONT1),
  Volt Control Bus Name,
  Volt Control Bus kV,
  RMA1,
  RMI1,
  VMA1,
  VMI1,
  NTP1,
  TAB1,
  CR1,
  CX1,
  WindV2,
  NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#,
Winding 1 Area Name,
Winding 1 Bus #,
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#,
Winding 2 Area Name,
Winding 2 Bus #,
Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#,
Winding 3 Area Name,
Winding 3 Bus #,
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBASE2-3,
R3-1,
Three Winding Transformer Data Fields - continued
X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus # (CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RMI1,
VMA1,
VMI1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued

RMI2,
VMA2,
VMI2,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RMI3,
VMA3,
VMI3,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields

In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (RJ),
DCVMIN,
CCCITMX,
CCCACC,
IPR REGION NAME,
IPR AREA#, 
IPR AREA NAME,
IPR Bus#, 
IPR BUS NAME,
IPR BUS kV,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#, 
ICR AREA NAME,
ICR BUS#, 
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#, 
IFR AREA NAME,
IFR BUS#, 
IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields
ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME, 
ITR BUS KV, 
IDR,
XCAPR, 
IPI REGION NAME,
IPI AREA#, 
IPI AREA NAME,
IPI Bus#, 
IPI BUS NAME, 
IPI BUS Kv, 
NBI, 
GAMMMX, 
GAMMN, 
RCI,
XCI, 
EBASI, 
TRI, 
TAPI, 
TMXI, 
TMNI, 
STPI, 
ICI REGION NAME, 
ICI AREA#, 
ICI AREA NAME, 
ICI BUS#, 
ICI BUS NAME, 
ICI BUS kV, 
IFI REGION NAME, 
IFI AREA#, 
IFI AREA NAME, 
IFI BUS#, 
IFI BUS NAME, 
IFI BUS kV, 
ITI REGION NAME, 
ITI AREA#, 
ITI AREA NAME, 
ITI BUS#, 
ITI BUS NAME, 
ITI BUS kV, 
IDI, 
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
SPP Model Development Procedure Manual

SECTION 8: APPENDIX II
UTILIZED IMPEDANCE CORRECTION TABLES
Table
Number

Tap or
Angle

1
Factor

Tap or
Angle

2
Factor

Tap or
Angle

3
Factor

Tap or
Angle

4
Factor

Tap or
Angle

5
Factor

Tap or
Angle

6
Factor

Tap or
Angle

7
Factor

Tap or
Angle

8
Factor

Tap or
Angle

9
Factor

Tap or
Angle

10
Factor

Tap or
Angle

11
Factor

1

-60

1

-36

0.358

-24.4

0.192

-12.4

0.054

-8.3

2

-70

1

-43

0.78

-32

0.85

0

0.5

32

0.024

0

0.01

8.3

0.024

12.4

0.054

24.4

0.192

36

0.358

60

1

0.85

43

0.78

70

1

0

0

0

0

0

0

0

3

-180

1

-150

0.5

0

0.5

150

0.5

0

180

1

0

0

0

0

0

0

0

0

0

0

0

0

4

-152

1

-121.5

0.625

-85.4

0.372

-42.2

8

-40

1.848

-30

1.468

0

1

30

0.217

0

0.157

42.2

0.217

85.4

0.372

121.5

0.625

152

1

0

0

0

0

1.538

40

1.83

0

0

0

0

0

0

0

0

0

0

0

10

-25

1.995

0

1

25

1.995

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

11

-25

1.995

0

1

25

0

1.995

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

12

-40

1.66

-29.5

1.331

0

-25.1

1.228

-20.6

1.145

0

1

20.6

1.145

25.1

1.228

29.5

1.331

40.1

1.66

0

0

0

13

-40

1.849

-30

0

1.402

-20

1.196

-10

1.045

0

1

10

1.045

20

1.161

30

1.366

40

1.741

0

0

0

16

-30

1.913

0

0

1

30

1.913

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

17

-47

0

6.34

-41.7

5.44

-33.3

4

-27.5

3.06

-18.5

2

0

1

18.5

1.76

27.5

3.278

33.3

3.643

41.7

5.25

47

18

1

-40

2.31

0

1

40

2.31

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

19

-40

7.35

-30

4.85

-20

2.9

-10

1.6

0

1

10

1.6

20

2.9

30

4.85

40

7.35

0

0

0

0

20

0.937

1.641

1

1

1.03

1.02

1.1

1.427

0

0

0

0

0

0

0

0

0

0

0

0

0

0

21

0.889

0.575

1.04

1

1.2

2.89

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

22

0.8

1.563

0.85

1.384

0.9

1.235

0.95

1.108

1

1

1.05

0.907

1.1

0.826

1.15

0.756

1.2

0.694

1.25

0.64

1.3

1

23

-10

1

5

0.655

20

1.449

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

25

-60

9.2

-46.38

4.69

-32.3

1.87

-20

1

0

1

18

1

32.3

3

46.38

5.54

60

9.2

0

0

0

0

31

-15

2.076

0

1

15

2.076

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

32

-15

1.62

0

1

15

1.62

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

33

-5.7

2.061

0

1

5.7

2.061

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

34

-10

1.782

0

1

10

1.782

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

35

-30

1.65

0

1

30

1.65

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

37

-15

2.076

0

1

15

2.076

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

40

-40

1

-35

0.75

-25

0.6

-12.5

0.55

-7.5

0.52

0

0.5

7.5

0.52

12.5

0.55

25

0.6

35

0.75

40

1

42

-42.5

1.784

-32.6

1.497

-22

1.26

-11.1

1.07

0

1

11.1

1.05

22

1.193

32.6

1.443

42.5

1.782

0

0

0

0

44

-52.9

1.9024

-43.6

1.6768

-33.7

1.4512

-23.2

1.2256

-12.3

1

-1.2

1.1385

9.9

1.2769

20.9

1.4154

31.4

1.5539

0

0

0

0

71


SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice
Designating MOD-032-1 Data Submittal Assignment

On this _____ day of __________, 20___, ___________________ and ____________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following:

On ____________, 20__, __________________, Data Owner, and __________________, Data Submitter, entered into an agreement through which _________________ has agreed to submit on behalf of ________________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

________________________________________________________________________________________________________________
________________________________________________________________________________________________________________
________________________________________________________________________________________________________________

The accuracy of the data is the responsibility of the Data Owner. This notice does not shift the compliance obligation from the Data Owner to the Data Submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER:    SPP hereby acknowledges receipt of this notice.
By: ______________________________    By: ______________________________
Printed Name: _____________________  Printed Name: _____________________
Title: _____________________________  Title: _____________________________
Date: _________________     Date: _________________

On behalf of DATA SUBMITTER:
By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: _______________
SECTION 10: APPENDIX IV SPP MODEL ON DEMAND (MOD) MATRIX

SPP MOD Project Type/Status Matrix

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Description</th>
<th>Applied to this Model Set:</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Transmission changes that materially-modify the SPP Transmission System. Projects associated with changing the generation or load components interconnected to the SPP Transmission System in accordance with SPP OATT Attachment V and AQ processes, are submitted separately under the &quot;Generation Interconnection&quot; or &quot;Attachment AQ Load&quot; MOD Types. MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number. Example Prj/Idv Name: 469_Patient_Gate_NTC305.jpr 469_BEPIC_Build_New_Line_SUS-4MM.jpr 469_Patient_Gate_PID2230.jpr</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>For material changes, Data Submitters shall submit an RMS ticket as a way of notifying SPP. The status for this MOD type will only be changed to &quot;Acknowledged&quot; by Data Submitters after receiving a notification from SPP for inclusion in the model sets.</td>
</tr>
<tr>
<td>SPP-approved Transmission System Upgrade</td>
<td>Must have an NTC for: 1) transmission service request(s); 2) transmission changes originating from the integrated transmission planning (ITP) process; 3) transmission changes originating from the Balanced Portfolio process; 4) transmission changes directed by the high priority study process; 5) transmission changes associated with Sponsored Upgrades.</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Study</td>
<td>Minimum transmission changes that have been acknowledged by SPP and may be included in model sets.</td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
<td>An expected change to the SPP Transmission System that does not yet have or does not require an NTC, including: 1) transmission changes budgeted for or planned by the TO; 2) transmission changes budgeted for by a Transmission Customer or other entity; 3) transmission changes resulting from an emergency (e.g., unplanned equipment failure); 4) transmission, load, or generation changes that otherwise have a strong likelihood or commitment to implement (e.g., load changes not yet approved by Attachment AQ, a GI with an IA but on suspension, a GI without an IA, etc.)</td>
<td>Acknowledged</td>
<td>X X X X X</td>
<td>Material transmission changes that have not yet been submitted to SPP and may not be included in model sets.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>This MOD Project Type &amp; Status is the default to represent transmission changes expected to be implemented in the future, but are not yet, or will not be, part of any SPP planning processes under Attachment O to the SPP OATT. Do not use this MOD Project Type to submit speculative changes to the transmission model that simply correct basecase system conditions (See MOD Project Type &quot;System Intact Alteration&quot;).</td>
</tr>
<tr>
<td>Attachment AQ</td>
<td>Changes to load and/or delivery points approved in accordance with Attachment AQ, including any transmission changes associated with the Attachment AQ project (e.g., equipment upgrades, changes to normally-open/closed topology).</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Study</td>
<td>Non-material transmission change that does not affect reliability or transmission service.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Load changes and transmission changes, including upgrades and changes to normally-open/closed topology, associated with the approved Attachment AQ load modification. MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number. Example Prj/Idv Name: 822_NextEra_Add_Blue_Cloud_Wind_GEN-20YY-###.prj: Example Prj/Idv Name: 822_NextEra_Add_Blue_Cloud_Wind_GEN-20YY-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_NTC2002 OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj</td>
</tr>
<tr>
<td>Generation Interconnection</td>
<td>Additions or changes to generating units, including any transmission changes associated with the Generation Interconnection Service project(s), approved in accordance with the Generator Interconnection Procedure (GIP) that: 1) have an executed Interconnection Agreement (IA) or executed Interim Generator Interconnection Agreement (IGIA), and 2) are not suspended.</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Study</td>
<td>Generation changes and transmission changes, including upgrades that may not have been included in the executed IA, associated with the approved GI. MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number. Example Prj/Idv Name: 822_NextEra_Add_Blue_Cloud_Wind_GEN-20YY-###.prj</td>
</tr>
<tr>
<td>Network Status</td>
<td>Changes to the existing SPP Transmission System network topological status only (both placed out-of-service or returned to service).</td>
<td>Update</td>
<td>X X X X X</td>
<td>Study</td>
<td>Projects with this status will be immediately committed to the MOD base case upon review.</td>
</tr>
<tr>
<td>Modeling Correction</td>
<td>Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD network data.</td>
<td>Update</td>
<td>X X X X X</td>
<td>Study</td>
<td>Projects with this status will not be submitted to any models except to those models submitted to MMWG.</td>
</tr>
<tr>
<td>System Intact Alteration</td>
<td>Changes to the transmission model necessary to correct basecase system intact voltage (e.g., to conform to MMWG voltage criteria), thermal criteria violations, or other basecase condition modifications (e.g., addition of an exploratory generating unit which provided resource for shorted).</td>
<td>Update</td>
<td>X X X X X</td>
<td>Study</td>
<td>Projects with this status will not be submitted to any models except to those models submitted to MMWG.</td>
</tr>
</tbody>
</table>

Notes:
- Projects associated with changing the generation or load components interconnected to the SPP Transmission System in accordance with SPP OATT Attachment V and AQ processes, are submitted separately under the "Generation Interconnection" or "Attachment AQ Load" MOD Types.
- MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number.
- Example Prj/Idv Name: 469_Patient_Gate_NTC305.jpr 469_BEPIC_Build_New_Line_SUS-4MM.jpr 469_Patient_Gate_PID2230.jpr
- For material changes, Data Submitters shall submit an RMS ticket as a way of notifying SPP. The status for this MOD type will only be changed to "Acknowledged" by Data Submitters after receiving a notification from SPP for inclusion in the model sets.
- This MOD Project Type & Status is the default to represent transmission changes expected to be implemented in the future, but are not yet, or will not be, part of any SPP planning processes under Attachment O to the SPP OATT. Do not use this MOD Project Type to submit speculative changes to the transmission model that simply correct basecase system conditions (See MOD Project Type "System Intact Alteration").
- Load changes and transmission changes, including upgrades and changes to normally-open/closed topology, associated with the approved Attachment AQ load modification.
- MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number. Example Prj/Idv Name: 822_NextEra_Add_Blue_Cloud_Wind_GEN-20YY-###.prj: Example Prj/Idv Name: 822_NextEra_Add_Blue_Cloud_Wind_GEN-20YY-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_NTC2002 OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj
- Generation changes and transmission changes, including upgrades that may not have been included in the executed IA, associated with the approved GI. MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number. Example Prj/Idv Name: 822_NextEra_Add_Blue_Cloud_Wind_GEN-20YY-###.prj
- Projects with this status will be immediately committed to the MOD base case upon review. Projects with this status will not be submitted to any models except to those models submitted to MMWG.
**SECTION 11: APPENDIX V MOD-032-1**

**ATTACHMENT 1**

**MOD-032-1 – ATTACHMENT 1**

The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near‐Term Transmission Planning Horizon and Long‐Term Transmission Planning Horizon. Data must be shareable on an interconnection‐wide basis to support use in the Interconnection‐wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity\(^{25}\) responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)</td>
<td>(If a user‐written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</td>
<td></td>
</tr>
<tr>
<td>1. Each bus [TO]</td>
<td>1. <strong>Generator</strong> [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>a. <strong>nominal voltage</strong></td>
<td>2. <strong>Excitation System</strong> [GO, RP (for future planned resources only)]</td>
<td>a. <strong>Positive Sequence Data</strong></td>
</tr>
<tr>
<td>b. <strong>area, zone and owner</strong></td>
<td>3. <strong>Governor</strong> [GO, RP (for future planned resources only)]</td>
<td>b. <strong>Negative Sequence Data</strong></td>
</tr>
<tr>
<td>2. Aggregate Demand(^{25}) [LSE]</td>
<td>4. <strong>Power System Stabilizer</strong> [GO, RP (for future planned resources only)]</td>
<td>c. <strong>Zero Sequence Data</strong></td>
</tr>
<tr>
<td>a. <strong>real and reactive power</strong></td>
<td>5. <strong>Demand</strong> [LSE]</td>
<td>2. <strong>Mutual Line Impedance Data</strong> [TO]</td>
</tr>
<tr>
<td>b. <strong>in-service status</strong></td>
<td>6. <strong>Wind Turbine Data</strong> [GO]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>3. Generating Units(^{26}) [GO, RP (for future planned resources only)]</td>
<td>7. <strong>Photovoltaic systems</strong> [GO]</td>
<td></td>
</tr>
<tr>
<td>a. <strong>real power capabilities</strong> - gross maximum and minimum values</td>
<td>8. <strong>Static Var Systems and FACTS</strong> [GO, TO, LSE]</td>
<td></td>
</tr>
<tr>
<td>b. <strong>reactive power capabilities</strong> - maximum and minimum values at real power capabilities in 3a above</td>
<td>9. <strong>DC system models</strong> [TO]</td>
<td></td>
</tr>
<tr>
<td>c. <strong>station service auxiliary load for normal plant configuration (provide</strong></td>
<td>10. Other information requested by the Planning Coordinator or</td>
<td></td>
</tr>
</tbody>
</table>

\(^{25}\) For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

\(^{26}\) For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

\(^{3}\) Including synchronous condensers and pumped storage.
<table>
<thead>
<tr>
<th>Required Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Power Plant (or Source)</td>
</tr>
<tr>
<td>a. name of plant</td>
</tr>
<tr>
<td>b. nominal MVA</td>
</tr>
<tr>
<td>c. machine MVA base</td>
</tr>
<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
</tr>
<tr>
<td>e. machine MVA base</td>
</tr>
<tr>
<td>f. generator step up transformer data (provide same data as that required for</td>
</tr>
<tr>
<td>transformer under item 6, below)</td>
</tr>
<tr>
<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
</tr>
<tr>
<td>h. in-service status*</td>
</tr>
<tr>
<td>2. Load Center or Market Area (or area of interest)</td>
</tr>
<tr>
<td>a. demand data (provide same data as that required for aggregate Demand under</td>
</tr>
<tr>
<td>item 2, above)</td>
</tr>
<tr>
<td>3. AC Transmission Line or Circuit [TO]</td>
</tr>
<tr>
<td>a. impedance parameters (positive sequence)</td>
</tr>
<tr>
<td>b. susceptance (line charging)</td>
</tr>
<tr>
<td>c. ratings (normal and emergency)*</td>
</tr>
<tr>
<td>d. in-service status*</td>
</tr>
<tr>
<td>4. AC Transmission Line or Circuit [TO]</td>
</tr>
<tr>
<td>a. impedance parameters (positive sequence)</td>
</tr>
<tr>
<td>b. susceptance (line charging)</td>
</tr>
<tr>
<td>c. ratings (normal and emergency)*</td>
</tr>
<tr>
<td>d. in-service status*</td>
</tr>
<tr>
<td>5. DC Transmission systems [TO]</td>
</tr>
<tr>
<td>a. nominal voltages of windings</td>
</tr>
<tr>
<td>b. impedance(s)</td>
</tr>
<tr>
<td>c. tap ratios (voltage or phase angle)*</td>
</tr>
<tr>
<td>d. minimum and maximum tap position limits</td>
</tr>
<tr>
<td>e. number of tap positions (for both the ULTC and NLTC)</td>
</tr>
<tr>
<td>f. regulated bus (for voltage regulating transformers)*</td>
</tr>
<tr>
<td>g. ratings (normal and emergency)*</td>
</tr>
<tr>
<td>h. in-service status*</td>
</tr>
<tr>
<td>6. Transformer (voltage and phase-shifting) [TO]</td>
</tr>
<tr>
<td>a. nominal voltages of windings</td>
</tr>
<tr>
<td>b. impedance(s)</td>
</tr>
<tr>
<td>c. tap ratios (voltage or phase angle)*</td>
</tr>
<tr>
<td>d. minimum and maximum tap position limits</td>
</tr>
<tr>
<td>e. number of tap positions (for both the ULTC and NLTC)</td>
</tr>
<tr>
<td>f. regulated bus (for voltage regulating transformers)*</td>
</tr>
<tr>
<td>g. ratings (normal and emergency)*</td>
</tr>
<tr>
<td>h. in-service status*</td>
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<td>7.</td>
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<td>8.</td>
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<td>9.</td>
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</tbody>
</table>
Southwest Power Pool, Inc.
Model Development Working Group
Conference Call
September 18th: 9:00 A.M. – 11:00 A.M. (CDT)

• M I N U T E S •

Agenda Item 1 – Administrative Items:

– Agenda Item 1a and 1b – Call to Order & Antitrust Statement:
The meeting was called to order at approximately 9:01 a.m and was proceeded by Sunny Raheem reading the anti-trust statement. Nate Morris notified Jerad Ethridge and Sunny Raheem for assigning Jerad the Chair position for the current meeting due to another meeting conflict.

– Agenda Item 1c and 1d – Attendance and Proxies:
The following MDWG members and guests attended.

MDWG Members present:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nate Morris</td>
<td>No</td>
<td>Jerad Ethridge</td>
<td>Empire District Electric Company, MDWG Chair</td>
</tr>
<tr>
<td>Jerad Ethridge</td>
<td>YES</td>
<td></td>
<td>Oklahoma Gas &amp; Electric, MDWG Vice-Chair</td>
</tr>
<tr>
<td>Charles Aleman</td>
<td>YES</td>
<td></td>
<td>Golden Spread Electric Cooperative</td>
</tr>
<tr>
<td>Andrew Berg</td>
<td>YES</td>
<td></td>
<td>Missouri River Energy Services</td>
</tr>
<tr>
<td>Preston Blinsky</td>
<td>YES</td>
<td></td>
<td>Basin Electric Power Cooperative</td>
</tr>
<tr>
<td>John Boshears</td>
<td>YES</td>
<td></td>
<td>City Utilities of Springfield</td>
</tr>
<tr>
<td>Joe Fultz</td>
<td>NO</td>
<td>Diego Toledo</td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Jeremy Harris</td>
<td>YES</td>
<td></td>
<td>KCP&amp;L and Westar, Every Companies</td>
</tr>
<tr>
<td>Jason Hofer</td>
<td>YES</td>
<td></td>
<td>Nebraska Public Power District</td>
</tr>
<tr>
<td>Steve Hohman</td>
<td>YES</td>
<td></td>
<td>Omaha Public Power District</td>
</tr>
<tr>
<td>Holli Krizek</td>
<td>YES</td>
<td></td>
<td>Western Area Power Administration</td>
</tr>
<tr>
<td>Jordan Lamb</td>
<td>NO</td>
<td></td>
<td>East River Electric Power Cooperative</td>
</tr>
<tr>
<td>Reené Miranda</td>
<td>NO</td>
<td>Aravind Chellappa</td>
<td>Southwestern Public Service</td>
</tr>
<tr>
<td>Alex Mucha</td>
<td>YES</td>
<td></td>
<td>Oklahoma Municipal Power Authority</td>
</tr>
<tr>
<td>Scott Rainbolt</td>
<td>YES</td>
<td></td>
<td>American Electric Power</td>
</tr>
<tr>
<td>Scott Schichtl</td>
<td>YES</td>
<td></td>
<td>Arkansas Electric Cooperative Company</td>
</tr>
<tr>
<td>Jason Shook</td>
<td>YES</td>
<td></td>
<td>GDS Associates</td>
</tr>
<tr>
<td>Liam Stringham</td>
<td>YES</td>
<td></td>
<td>Sunflower Electric Power Corporation</td>
</tr>
<tr>
<td>Sunny Raheem</td>
<td>YES</td>
<td></td>
<td>Southwest Power Pool, Inc., MDWG Secretary</td>
</tr>
</tbody>
</table>

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
**Antitrust:** SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.

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**Additional Guests present:**

<table>
<thead>
<tr>
<th>Guests</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Josh Hesselbein</td>
<td>Arkansas Electric Cooperative</td>
</tr>
<tr>
<td>Jerry Bradshaw</td>
<td>City Utilities of Springfield</td>
</tr>
<tr>
<td>Cristina Ortiz, Lafayette Gatewood, Pallab Datta, Marcus Moor, Ryan Baysinger</td>
<td>Evergy Companies</td>
</tr>
<tr>
<td>Diego Toledo, Dona Parks</td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Bryan Haslinger</td>
<td>ITC Great Plains</td>
</tr>
<tr>
<td>Alan Burbach</td>
<td>Lincoln Electric System</td>
</tr>
<tr>
<td>Calvin Coates</td>
<td>Kansas City Board of Utilities</td>
</tr>
<tr>
<td>James Ging</td>
<td>Kansas Power Pool</td>
</tr>
<tr>
<td>Armin Sehic</td>
<td>Municipal Energy Agency of Nebraska</td>
</tr>
<tr>
<td>Kevin Samuel</td>
<td>NextEra Energy Resources</td>
</tr>
<tr>
<td>Kim Farris, Michael Odom, Moses Rotich</td>
<td>Southwest Power Pool, Inc.</td>
</tr>
<tr>
<td>Scott Mijin</td>
<td>Southwestern Power Administration</td>
</tr>
<tr>
<td>Aravind Chellappa</td>
<td>Southwestern Public Service</td>
</tr>
<tr>
<td>Tanner New</td>
<td>Sunflower Electric Cooperative</td>
</tr>
<tr>
<td>Brianna Haug, Garrick Nelson, Holli Krizek</td>
<td>Western Area Power Administration</td>
</tr>
<tr>
<td>Joe Williams</td>
<td>Western Farmers Electric Cooperative</td>
</tr>
</tbody>
</table>
- Agenda Item 1e(i) – Agenda Review (Approval Item):
Jerad Ethridge asked the group if they had any modifications to the agenda. The group did not voice any modifications.

Scott Schichtl motion approve agenda as presented on the screen. Jason Hofer seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

Background Material for Motion: SEPT18_MM_Attach1 - 1e. MDWG Meeting Agenda 20190918.docx

Agenda Item 2 – 2019 MDWG Model Series:
Sunny Raheem provided an overview of the posted proposed final models and files. Sunny outlined the number of conventional generators converted to GENTPJ models and number of renewable models converted to PSSE supported models since the start of the model build project. Sunny summarized the model changes received since posting the proposed final models. Sunny mentioned there were quite a few updates that staff received and reviewed by the start of this meeting. Staff recommended approving the models with post processing updates. The group discuss the types of updates and best path forward approving the models with minimum schedule impact. A member of the group mentioned they would like to work with staff to address some fatal error message the member received. After discussion, the group decided to facilitate the model approval the following week via email voting protocol to allow staff to include all the acceptable changes into the models.

Action Item: Staff to post final dynamic models with recent acceptable model updates the following week

Staff posted the updated proposed final models on September 24, 2019. The group received an email motion from Scott Schichtl motion to approve the updated 2019 MDWG proposed final dynamic cases set as final on September 26, 2019. Andy Berg seconded the motion. The email vote started September 26, 2019 and ended September 30, 2019. The motion passed unanimously.
Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.

Agenda Item 3—Administrative Items:

- Agenda Item 3a – Summary of Action Items:
  - Staff to post final dynamic models with recent acceptable model updates the following week

- Agenda Item 3b – Future Meetings:
  Jerad provided an overview of future meetings.

- Agenda Item 3c – Adjourn Meeting:

  Scott Schichtl motioned to adjourn the meeting. Jason Shook seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

  The meeting adjourned at 9:26 AM (CDT).

Respectfully submitted,
Sunny Raheem
MDWG Secretary
## Status Legend

<table>
<thead>
<tr>
<th>Status Indicator</th>
<th>Status</th>
<th>Milestone Tasks Are...</th>
</tr>
</thead>
<tbody>
<tr>
<td>★</td>
<td>Complete</td>
<td>Completed on-time</td>
</tr>
<tr>
<td></td>
<td>On Track</td>
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<td>▲</td>
<td>Monitor/At Risk</td>
<td>Being monitored for potential schedule/study impact(s)</td>
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<td>▼</td>
<td>Late/Delayed</td>
<td>Completed late/behind schedule</td>
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<tr>
<td>■</td>
<td>In Mitigation</td>
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2020 ITP
# CURRENT AND UPCOMING MILESTONES

<table>
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<tr>
<th>Milestone</th>
<th>Status</th>
<th>Start Date</th>
<th>End Date</th>
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<tr>
<td>In mitigation; project end date not currently at risk</td>
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<td>12/31/2019</td>
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<tr>
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<td>1/27/2020</td>
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<tr>
<td>Needs Assessments</td>
<td>🟠</td>
<td>11/07/2019</td>
<td>3/12/2020</td>
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MITIGATION AND GO GREEN PLAN

• Mitigation
  • MEM-Pass 3 models approved by ESWG on 11/1 for use in Constraint Assessment milestone
  • Updated final Powerflow and Short-Circuit models approved final by TWG on 11/15/19
  • Two critical milestones in progress and being monitored:
    • Constraint Assessment - in progress and currently scheduled to post 12/10 for stakeholder review
    • MPM Build - preliminary work in progress with proxy data to possibly regain back some of the 15 days lost during MEM build
  • Experienced constrained resources due to work overlap finalizing the 2019 ITP
  • Project end date not currently impacted; however, schedule is being re-evaluated to determine whether or not additional time will be available for the Study Cost Estimate windows

• Go Green Plan
  • Reduce duration of needs assessment to open DPP window sooner than 3/12/20
    • Stakeholders will be notified of DPP window dates by 12/06/19
  • Schedules are being re-evaluated to determine re-baseline for remainder of schedule, as well as looking for possible efficiencies to regain days lost
2021 ITP
## Current and Upcoming Milestones

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<th>Milestone</th>
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<td>Powerflow Model Development</td>
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<td>7/08/2019</td>
<td>3/06/2020</td>
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<td>Load and Generation Review</td>
<td>![On Track]</td>
<td>7/16/2019</td>
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<td>8/09/2019</td>
<td>3/06/2020</td>
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<td>Renewable Policy Review</td>
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<td>2/14/2020</td>
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<tr>
<td>Renewable Resource Plan – Phase 1</td>
<td>![On Track]</td>
<td>2/03/2020</td>
<td>3/05/2020</td>
</tr>
</tbody>
</table>
Southwest Power Pool, Inc.
MODEL DEVELOPMENT WORKING GROUP
December 13th, 2019
Conference Call
• A G E N D A •
9:00 a.m. – 11:00 a.m. (CST)

1. Administrative Items ........................................................................................................... Jerad Ethridge
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials

2. 2019 series MDWG Dynamic Models for SPP 2020 TPL (Approval Item*) ........... Shahrokh Akhlaghi

3. Administrative Items ...................................................................................................... Jerad Ethridge
   a. Summary of Action Items
   b. Future Meetings
      i. MDWG
         1. Next Face-to-Face: January 22nd, 2020 AEP Offices Dallas TX (8:30AM – 4:00PM CST)
      ii. Manual Task Force:
         1. Biweekly on Thursday 9:00am-11:00am (CST)
      iii. Focus Groups Meetings:
         1. Power Flow: December 16th, 2019 (9:30AM – 11:30AM CST)
         2. Short Circuit: TBD – Pending Group Discussion
         3. Dynamics: TBD – Pending Meeting Survey Responses
         4. Model Dispatch: TBD – Pending Meeting Survey
   c. Adjourn

Note: The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG.
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. None
Motions:

1. Andy Berg motioned to approve the agenda. The motion passed unanimously.

2. Andy Berg motioned to approve the 2019 series MDWG dynamic models for SPP 2020 TPL as posted. The motion passed with no opposition and one abstention.

3. Andy Berg motioned to adjourn the meeting. The motion passed unanimously.
AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

Prior to the meeting, SPP MDWG Chair Nate Morris assigned his Chair responsibilities to Jerad Ethridge. Sunny Raheem assigned his SPP MDWG Secretary responsibilities to Moses Rotich.

SPP MDWG Vice-Chair, Jerad Ethridge, called the meeting to order at 9:02 am with Quorum. SPP Staff Secretary Proxy, Moses Rotich, reading the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES
The following members attended or represented by proxy:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Present</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nate Morris</td>
<td>NO</td>
<td>Jerad Ethridge</td>
<td>YES</td>
<td>Empire District Electric Company, MDWG Chair</td>
</tr>
<tr>
<td>Jerad Ethridge</td>
<td>YES</td>
<td></td>
<td></td>
<td>Oklahoma Gas &amp; Electric, MDWG Vice-Chair</td>
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<tr>
<td>Charles Aleman</td>
<td>YES</td>
<td></td>
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<td>Golden Spread Electric Cooperative</td>
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<tr>
<td>Andrew Berg</td>
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<td>Missouri River Energy Services</td>
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<td>John Boshears</td>
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<tr>
<td>Joe Fultz</td>
<td>NO</td>
<td>Kiet Nguyen</td>
<td>YES</td>
<td>Grand River Dam Authority</td>
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<td>Jeremy Harris</td>
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<td></td>
<td>KCP&amp;L and Westar, Evergy Companies</td>
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<td>Jason Hofer</td>
<td>YES</td>
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<td>Nebraska Public Power District</td>
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<td>Steve Hohman</td>
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<td>Omaha Public Power District</td>
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<td>Holli Krizek</td>
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<td>Western Area Power Administration</td>
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<td>Jordan Lamb</td>
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<td>Reené Miranda</td>
<td>NO</td>
<td>Aravind Chellappa</td>
<td>YES</td>
<td>Southwestern Public Service</td>
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<td>Alex Mucha</td>
<td>YES</td>
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<td>Oklahoma Municipal Power Authority</td>
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<td>Scott Rainbolt</td>
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<td>American Electric Power</td>
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<td>Scott Schichtl</td>
<td>YES</td>
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<td>Arkansas Electric Cooperative Company</td>
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<tr>
<td>Jason Shook</td>
<td>YES</td>
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<td>GDS Associates</td>
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<td>Liam Stringham</td>
<td>YES</td>
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<td>Sunflower Electric Power Corporation</td>
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<td>Sunny Raheem</td>
<td>NO</td>
<td>Moses Rotich</td>
<td>Yes</td>
<td>Southwest Power Pool, Inc., MDWG Secretary</td>
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### Additional Guests:

<table>
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<th>Guests</th>
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<tr>
<td>Josh Hesselbein</td>
<td>Arkansas Electric Cooperative</td>
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<td>David Zhong</td>
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<td>Jerry Bradshaw</td>
<td>City Utilities of Springfield</td>
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<tr>
<td>Jeff Crites</td>
<td>The Empire District</td>
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<tr>
<td>Pallab Datta, Marcus Moor, Ryan Baysinger</td>
<td>Evergy Companies</td>
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<tr>
<td>Kiet Nguyen</td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Alan Burbach, Elaine Sun</td>
<td>Lincoln Electric System</td>
</tr>
<tr>
<td>Armin Sehic</td>
<td>Municipal Energy Agency of Nebraska</td>
</tr>
<tr>
<td>Mark Mallard</td>
<td>Northwestern</td>
</tr>
<tr>
<td>Tom Mayhan</td>
<td>Omaha Public Power District</td>
</tr>
<tr>
<td>Jeff McDiarmid, Lottie Richardson, Michael Odom, Moses Rotich, Shahrokh Akhlaghi, Zach Sabey</td>
<td>Southwest Power Pool, Inc.</td>
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<tr>
<td>David Sargent, Scott Mijn</td>
<td>Southwest Power Administration</td>
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<td>Aravind Chellappa, Frank Favela</td>
<td>Southwestern Public Service</td>
</tr>
<tr>
<td>Joe Williams</td>
<td>Western Farmers Electric Cooperative</td>
</tr>
</tbody>
</table>
AGENDA ITEM 1E – AGENDA REVIEW

Jerad Ethridge asked the group if they had chance to review the agenda and if the group has any modifications to the agenda. The group did not voice any modifications.

**Motion:** Andy Berg motioned to approve the agenda. Alex Mucha seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

Material: DEC13_MM_Attach1 - 1e. MDWG Meeting Agenda 20191213.docx

AGENDA ITEM 2 – 2019 SERIES MDWG DYNAMIC MODELS FOR SPP 2020 TPL (APPROVAL ITEM*)

Shahrokh Akhlaghi presented the overview for the 2019 series MDWG dynamic models for SPP 2020 TPL. Shahrokh mentioned the SPP Board of Director NTC decisions and approvals are accounted for in the models. Additionally, 2020 ITP Section 10.3 model corrections are applied to the models. Shahrokh mentioned he observed some oscillation for a few wind farms after the updates. The group requested follow up with the wind farm owner. The group discussed the number of updates provided since posting of the proposed final TPL models.

**Motion:** Andy Berg motioned to approve the 2019 series MDWG dynamic models for SPP 2020 TPL as posted. Scott Rainbolt seconded the motion. The group discussed MOD-026/27 updates and their applicability to the models after Transmission Planners have validated the testing. The group discussed when the updated models would be posted. Staff mentioned the updated models will be posted the following Monday. The group discussed PSSE version 34 challenges and NERC acceptable model list during the discussion of the motion. The motion passed with no opposition and one abstention from Aravind Chellappa.
AGENDA ITEM 3 – ADMINISTRATIVE ITEMS

AGENDA ITEM 3A – SUMMARY OF ACTION ITEMS

No current meeting action items

AGENDA ITEM 3B – FUTURE MEETINGS

Staff outlined the future MDWG, MDWG focus groups, and MDWG manual task force meetings

AGENDA ITEM 3C – ADJOURN

Jerad asked the group if they had any other topics for discussion before the group adjourned. Moses communicated reminders about the current model builds. The group did not voice any additional topics.

Motion: Andy Berg motioned to adjourn the meeting. Jeremy Harris seconded the motion. The group did not voice concern during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at 9:36 am (CST).

Respectfully Submitted,

Moses Rotich, Sunny Raheem

Staff, Secretary
Attachments

DEC13_MM_Attach1 - 1e. MDWG Meeting Agenda 20191213.docx
## REVISION HISTORY

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<th>CHANGE DESCRIPTION</th>
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, Data Owners, equipment, and Data Submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1), and the provisions of the

1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

---

\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

**Applicable Data Submitters**

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

A completed Letter of Notice identifying responsibilities between a Data Owner and a Data Submitter is required to be submitted to SPP. This Letter of Notice is included in the appendix section.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

---

4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the Bulk Electric System (BES).
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.

---

5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Sixth Revised Volume No.1, Attachment AI, Part II-1.
8 Sixth Revised Volume No.1, Attachment AI, Part II-2.
9 Sixth Revised Volume No.1, Part III-30.
10 Sixth Revised Volume No.1, Part III-31.
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- Appropriate lead times. Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes. In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship

The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set

The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users

The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users

For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models.
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models [case types] can be found on the SPP corporate website, www.spp.org.

Data Transmittal
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic --** GlobalScape

2. **E-MAIL --** SPPEngineeringModeling@spp.org

The preferred method of submittal is through the "SPP MDWG File Sharing Site", GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. See Section 6-B for a sample file format. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

SPP Model Release Guidelines
Steady-State and Short Circuit Models

SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables
Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abrreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   a. Steady-State RAWD case file
   b. Conversion IDEV files

2. Dynamics Cases
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP’s GlobalScape under Modeling (CEII, RSD) → SPP Modeling Contacts → 3. Final Modeling Contacts

NOTE – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

Compliance

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power Flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, long name, and associated Auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts that meet TPL-001 requirements shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be not coincident to the SPP region, meaning that the hour that a Data Submitter's system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g., arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter's load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such
location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have an updated service agreement, or are in the process of finalizing a service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS® idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Not Coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

On-Peak/Off-Peak Models
Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority Coincident Peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Should Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
</tbody>
</table>

Typically 70% - 80% of Summer On-Peak load level

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.
Load Data
Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the EDST.

Area Summary Report
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations listed in Section 6-B should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity's model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

Tie Line Coordination
Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

Line and Transformer Data
Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The "from bus," "to bus," and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The "from bus" is assumed to be the metered end (unless the "to bus" is entered with a negative) and the "to bus" area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the "from bus" or first bus number after the change code. The "from bus" is the metered end unless the "to bus" or second bus number is a negative number. Remember to include the circuit identifier.
3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional.

6. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

7. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range. (see Section 6-B). For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).
NOTE: When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

1. Below 69 kV  4. 138 kV  7. 345 kV
2. 69 kV  5. 161 kV  8. 500 kV
3. 115 kV  6. 230 kV  9. 765 kV or above

1. For generator regulated buses, a desired voltage set point will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the Station Service or Auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.
Generator Data
Generating unit MW and MVAR output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits with consideration of MOD-025-2 and SPP Planning Criteria 7.1.1, or company-specific procedure for testing the gross capability of the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with Auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities.

For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to XSOURCE Table.

For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour.

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance information is provided.

When modeling mothballed and future retired units, the unit will be modeled offline (in-service status = 0). The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. Similar to units that are not dispatched in the particular seasonal model. Unit retirement information will be provided in a separate document and posted through a secure website. Decommissioned units should be removed from the models.

Modeling Process for Generator Parameters
a. The Generator parameter P_{MAX} shall be modeled as a gross seasonal maximum capability based on SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.
b. Generating plant Station Service load and Auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All Station Service load and Auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus, corresponding to the voltage to which the Auxiliary load is served. Model representations of Auxiliary load connected to the generating unit bus (Figure VII-1), Auxiliary load modeled with separate transformation (Figure VII-2), and Auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

![Diagram of bus representations](image)

**Figure VII-1. Common bus representation**  
**Figure VII-2. Separate transformation representation**  
**Figure VII-3. Transformer high-side representation**

c. Experience has shown that generating plant Station Service load and Auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant Station Service load and Auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable Station Service load and Auxiliary load.

If generating plant Station Service load and Auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant Station Service load and Auxiliary load shall use “Sn” in the Load ID for one or more aggregated generating plant Station Service loads (Figure VII-4a).

If generating plant Station Service load and Auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant Station Service load and Auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b).

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11 Station Service load and Auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant Auxiliary load.
VII-4b. The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “Fn” in the Load ID field to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “Vn” in the Load ID field to designate variable load quantities that do vary with plant dispatch.

Figure VII-4. Examples of generating plant Auxiliary load representations (aggregated, combined, and discrete).

Only generating plant Station Service load or Auxiliary load IDs should be labeled with “Sn”, “Fn”, or “Vn”, all other load types should be labeled differently.

Generating plant Station Service load or Auxiliary load IDs of “Sn” or “Vn” should be modeled such that the in-service status of the load follows the in-service status of the generator in which it is connected. For example: Generator 1 is offline, then the associated generating plant Station Service load or Auxiliary load with load IDs of “Sn” or “Vn” should also be offline.

Station Service (SS) or Auxiliary (Aux) load modeling should be done in accordance with the state of the generator as follows:

<table>
<thead>
<tr>
<th>Generator State</th>
<th>Aggregated “Sn” SS or Aux Load</th>
<th>Variable “Vn” SS or Aux Load</th>
<th>Fixed “Fn” SS or Aux Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>In-Service</td>
<td>In-Service</td>
<td>In-Service</td>
</tr>
<tr>
<td>Offline</td>
<td>In-Service</td>
<td>Off-line</td>
<td>In-Service</td>
</tr>
<tr>
<td>Decommissioned</td>
<td>Removed from model</td>
<td>Removed from model</td>
<td>Removed from model</td>
</tr>
</tbody>
</table>

The Generator Parameters for PMIN, AUX Load, QMAX, and QMIN shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

Modeling of Wind/Solar Renewable Resources $P_{\text{GEN}}$

- Spring Light Load Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP minimum load hour corresponding

$"n"$ represents a unique numeric value. PSS/E requires each load placed at a bus to have a unique Load ID.
to the season of the Light Load case, not to exceed each facility’s firm service amount. The methodology used to calculate replacement data is described in the ITP Manual. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

- On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident\textsuperscript{13} peak, not to exceed each facility’s firm service amount.

- SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of each SPP MDWG model build. Any renewable resource modeling data submitted to the PC, after the initial dispatch list is provided, will be dispatched at the seasonal state dispatch percentage of the renewable resource’s nameplate amount.

- When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

- Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

- For resources that do not have firm service, \( P_{\text{GEN}} \) values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

\textsuperscript{13} SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

\textbf{Effective date of sections 1&3 is in effect.}
\textbf{Effective date of section 2 is July 1, 2016.}
\textbf{Effective date of section 4 is July 1, 2016.}

\textbf{Shortfall Guidance Process}
Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   a. The in-service date shall be based on the expected in-service date of the GI study.
   b. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of 2x (where x is any second ID designation appropriate in PSS®E).
c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future Exploratory Generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future Exploratory Generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, Exploratory Generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of Exploratory Generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

**EXTERNAL RESOURCE MODELING**

**Purpose**
This procedure assures that members adhere to a uniform process when modeling external resources in SPP.

**Modeling Process**
If a member acquires external resources outside their Model Area, the following modeling process should be followed:
1. All buses should be assigned numbers that are in the host’s Model Area bus number range.
2. Area Number/Name should be the host’s Model Area number.
3. Zone Number/Name should be in the host’s Model Area zone range.
4. Generation Owner Number should be the owner's designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

**Owner Data and Line Mileage Data (SSAE Control)**
To meet the Statement on Standards for Attestation Engagement (SSAE) requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:
1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

**Initial Run Review**
After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.
1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
   Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
   The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.
a. **Voltage Summaries**

Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.
The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. \( QT \rightarrow \text{MAX} = \text{one-half of MW rating} \)

ii. \( QB \rightarrow \text{MIN} = \text{negative one-third of MW rating} \)

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure to update MOD.
2. Submitting a PTI IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data
for that bus will be removed (e.g., branches, transformers, generators, and loads). **The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified.** Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have "Area interchange control" with the "Tie Line and Loads" option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
6. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**STEADY-STATE MODELING REQUIREMENTS**

**GENERATORS**

1. All steady-state generators, including synchronous condensers and Static Var Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-
state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the XSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

**XSOURCE Table:**

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS FOR XSOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous:</td>
<td></td>
</tr>
<tr>
<td>Detailed Subtransient</td>
<td>Unsaturated sub-transient reactance ( X''_d ) [PU]</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Synchronous:</td>
<td></td>
</tr>
<tr>
<td>Non-Detailed</td>
<td>Unsaturated transient reactance ( X'_d ) [PU]</td>
</tr>
<tr>
<td>Classical</td>
<td></td>
</tr>
<tr>
<td>or Transient</td>
<td></td>
</tr>
<tr>
<td>Renewable:</td>
<td></td>
</tr>
<tr>
<td>Wind Type 1</td>
<td>Unsaturated transient reactance ( X'_d ) of single machine [PU*]</td>
</tr>
<tr>
<td>Wind Type 2</td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>Locked rotor reactance (sum of rotor and stator leakage reactances)</td>
</tr>
<tr>
<td></td>
<td>[PU]</td>
</tr>
<tr>
<td>Renewable:</td>
<td></td>
</tr>
<tr>
<td>Wind Type 3</td>
<td>Unsaturated transient reactance ( X'_d ) of single machine [PU]</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Renewable:</td>
<td></td>
</tr>
<tr>
<td>Inverter-Based</td>
<td>( V_{\text{rated}} = \text{Rated Voltage} = 1.0 ) [PU] (assumed)</td>
</tr>
<tr>
<td>Solar PV</td>
<td>( I_{\text{rated}} = \text{Rated Current From GO} ) [PU]</td>
</tr>
<tr>
<td>Wind Type 4</td>
<td>( X_{\text{Source}} = \frac{V_{\text{rated}}}{I_{\text{rated}}} ) [PU]</td>
</tr>
<tr>
<td>Renewable:</td>
<td></td>
</tr>
<tr>
<td>Wind Type 5</td>
<td>Unsaturated sub-transient reactance ( X''_d ) [PU]</td>
</tr>
</tbody>
</table>

* PU values should be based on the rated terminal voltage and machine MVA base

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation. If a user model representing particular SVC
and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:
   a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used
   b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation
   c. Different development phases
      i. These representations should be combined as the phases are placed in service as applicable

OTHER DEVICES

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

   If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to "load net" (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model
bus ties using R=0.00000 + X=0.0001 and B=0.00000. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of R=0.0001 + X=0.002 and B=0.00000. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers - To adequately model transformers, the following parameters, at a minimum, are required:
   a. **Nominal voltage of windings and bus reference to which the appropriate winding is connected**
      When entering transformer data, the rated voltage\(^{14}\) for all applicable windings should be specified. For non-LTC transformers, the winding voltage should be set to the tap voltage.
      
      A recommended approach is to model three-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 1
      - X, or Low-Voltage, Winding = Winding 2
      - Y, or Tertiary-Voltage, Winding = Winding 3
      
      A recommended approach is to model two-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 2
      - X, or Low-Voltage, Winding = Winding 1

      The two-winding\(^{15}\) transformer winding map is in this order by default since PSS®E requires all two-winding transformers with Load Tap Changers (LTCs) to specify the tap bus as Winding 1. While not all LTC transformers have the tap on the X winding, this is common with most transformers.

   b. **Impedance(s)**

      A recommended approach to modeling transformer impedance is to set the winding MVA base to the system MVA base which is 100 MVA, entered as positive sequence data in pairwise (delta) format. Care should be taken to when entering transformer impedance data to ensure that the data entered corresponds to the appropriate base (system or winding).

\(^{14}\) Care should be taken to enter the rated voltage, which may be different than the nominal voltage of the system for all transformer windings. There can be a difference between the rated voltage of the system and the transformer (nominal).

\(^{15}\) Two winding representation in PSS®E allows the user to select which bus number (from or to) the winding 1 resides.
Enter zero sequence data in the format appropriate to the connection code.

Connection codes <10:
- The zero sequence data must be entered as T-model format.

Connection codes >10:
- The zero sequence data must be entered in pairwise (delta) format.

c. Tap ratios
Depending on the PSS®E winding code used for the transformer, the setting should be either p.u. or kV. It should be noted, “tap ratio”, “winding ratio”, and “turns ratio” are synonymous.
- For transformers with no taps, use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
- For transformers with automatically adjusting, under-load tap changers (ULTC), it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
  - For parallel transformers, it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio for both transformers in order to prevent circulating VARs.
- For transformers with non-automatically adjusting, under-load tap changers (ULTC), it is recommended to use the tap ratio as set in the field.
- For transformers with no-load tap changers (NLTC), it is recommended to use the tap ratio as set in the field.
- It is recommended that Delta-Wye phase angle differences are incorporated appropriately in the models.

d. Minimum and maximum tap position limits
- Minimum and maximum tap position limits (RMIN and RMAX) shall be modeled based on transformer test report or manufacturer nameplate data.

e. Number of tap positions (for both the ULTC and NLTC)
- Under-load tap changers (ULTC) control bus, total number of tap positions, and tap setting shall be specified.
- No-load tap changers (NLTC) total number of tap positions and the tap setting shall be specified.
- Transformer tap positions are discrete. The total number of transformer tap positions is a fixed quantity and shall be entered. The maximum and minimum transformer tap positions represent the physical boundaries of the transformer’s capability to modify its winding impedance to achieve a control objective. Transformer tap changing control modes may include voltage regulation, as well as real and reactive power control. Automatically-adjusting under-load tap changing transformers (ULTC) shall specify a control mode, the bus that is being controlled, and the control limits defined by the maximum and minimum transformer tap positions.

16 It is noted that PSS®E provides transformer tap changer limit fields called VMAX and VMIN, regardless of control mode. For example, if a real power control mode is selected, the user must enter MW quantities in the VMAX and VMIN fields.
For transformers with untapped windings, the number of tap positions shall be “99” to indicate that there are no taps. PSS®E does not allow a value of “1” to be used as a tap position.

f. Regulated bus (for voltage regulating transformers)
   - The regulated bus is the location where the transformer is regulating voltage. Typically this regulated bus is connected to a transformer winding bus.
   - A limit difference of less than 0.0125 p.u. shall not be used when entering the regulated voltage band limits (VMAX, VMIN) for an automatically adjusting, under-load tap changers (ULTC) transformer.
   - It is recommended that the voltage band limits VMAX and VMIN be no less than 0.025 p.u., to prevent toggling of the ULTC during simulation iterations.

g. In-service status
   - In-service status, set to zero (0) if the device is not in-service.

h. Vector group and Connection code
   - The vector group shall match the topological configuration of the buses representing where the windings are connected (e.g., A 115/69 kV load serving transformer with a vector group of Dyn11 must show the winding 1 bus [Delta winding] as the 115 kV bus).
   - Transformer connection codes\(^\text{17}\) and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.
   - The transformer core construction should be considered (shell type or core type)\(^\text{18}\)

i. Transformers Controlling Reactive Power Flow
   - The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10

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\(^{17}\) Reference PSS/E Program Operation Manual section: Two Winding Transformer Zero Sequence Network Diagrams and Connection Codes or Three Winding Transformer Zero Sequence Network Diagrams and Connection Codes.

\(^{18}\) Reference the TPL-007-1 Data Collection Template User Guide document under the Transformers section/Core Type. https://www.spp.org/spp-documents-filings/?id=197519
MVAR. Limits should accurately represent the actual operation of automatic control devices.

9. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes. PSTs will be represented in the planning models as two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:
   a. Real-time operational auto or manual adjustment operation of the PST.
   b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
   c. Real-time operational MW flow limits (e.g. ±20 MW).
   d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
   e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
   f. Applicable long-term firm transmission service levels for the PST.

11. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

12. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

13. Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

14. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step-up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.
15. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

17. Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

18. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

19. Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

20. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

21. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus nor should they be connected to the network with a zero impedance tie.

22. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service status equal to zero. In-service Static Var Systems should be modeled with an in-service status equal to one.
23. DC Transmission systems – DC transmission systems must be represented with a sufficiently detailed model to simulate its expected behavior.

24. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

25. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it.
   (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during Equivalencing.

4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. Fictitious regulation of buses.

12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under-load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, \( \theta_A < \theta_B \).
   c. Assuming \( \theta_A \) and \( \theta_B \) stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling\(^{19}\) is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area\(^{20}\). While typically analogous to a

\(^{19}\) The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

\(^{20}\) Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\(^{21}\) loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

\[\text{Figure 1. Example of interconnected model areas.}\]

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\(^{21}\) ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (P_{gen}) of each non-sack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load: loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:

---

**Figure 2. Four types of inter-SPP pseudo-ties.**

- **Pseudo-tie Into SPP**
  - Area Field of Bus = non-SPP
  - Area Field of Bus = SPP
  - SPP resource resides in non-SPP model area, but serves SPP load.

- **Pseudo-tie Out of SPP**
  - Area Field of Bus = SPP
  - Area Field of Bus = non-SPP
  - Non-SPP resource resides in SPP model area, but serves non-SPP load.

---

Source

Sink

---

Model area

SPP load resides in non-SPP model area, but served by SPP resource.

Non-SPP load resides in SPP model area, but served by non-SPP resource.

---

SPP resource resides in non-SPP model area, but serves SPP load.

Non-SPP resource resides in SPP model area, but serves non-SPP load.
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

### Data Owner A

![Diagram of Inter-area transfer (transaction).](image)

**Physical circuitry tie is irrelevant.**

**Source**

**Sink**

---

**Model area**

---

### Inter-area Bilateral transaction description

**Data Owner A exports MW to Data Owner B**  
**Data Owner B imports MW from Data Owner A**

### Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>MW</th>
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<tr>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 3. Example of Inter-area transfer (transaction).**
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.

Intra-area Bilateral transaction description

Data Owner A exports MW to Data Owner C
Data Owner C imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ED</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 1BM</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>XYZ122</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>500</td>
</tr>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>XYZ112</td>
<td>12/1/2011</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where external resource is located to the generation owner control area. If the external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area’s number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

No Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models reflect detailed dynamic model representations for SPP resources and equilized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPRL reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the SPP RTO with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:

5.1 Steady-State models
6.1 Files applied (if applicable) to steady-state models for dynamic initialization purposes
7.2 Dynamic model data in Siemens PTI PSS®E DYRE format
8.3 User written model source and object code

The schedule for submission of Dynamic data and list of MDWG Dynamic models [case types] can be found on the SPP corporate website, www.spp.org.

Dynamics Data Submittal Requirements and Guidelines

b.1 All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:

a. Detailed data is not available because manufacturer no longer in business.
b. Detailed data is not available because unit is older than 1970.

The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:

acd. Unit is on standby or mothballed and not carrying load in MMWG cases.

The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

b.2 All synchronous generators and condensers shall also include representations of the generator, excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:

da. Excitation system representation shall be omitted if unit is operated under manual excitation control.
b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
c.g. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
d.h. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

d. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), Flexible AC Transmission System (FACTS), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

d. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

e. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

f. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:

1. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
2. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

2. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

3. Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

4. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

5. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

6. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.
6.11. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

MINS Relay Models

1. If a generator has in-service frequency and voltage protective relays, then the relay models shall be provided by the GO to the Data Submitter or the SPP PC. The generator frequency and voltage protective relay models in PSS®E are in the category of "Miscellaneous Other" models. See the following item regarding "Miscellaneous Other" models.

2. PSS®E Model Instance (MINS) values for "Miscellaneous Other" models should be a unique eight digit number. The first six digits should be the bus number at which the model is being applied. The last two digits should be a unique number designating a particular application of a "Miscellaneous Other" model at the bus. Under no circumstance shall a unique eight digit MINS number be repeated.

PROCEDURE FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES

Note: PSS®E activities relevant to the following steps are shown in brackets.

7.3. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or −9999.
   c. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      vii. Overloaded generators. [GEO1]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      viii. Branches with extreme impedances or tap ratios [BRCH].

Suggested options are:
a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.
d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.
e) High tap ratios.
f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.
i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default FMAX (+9999) and PMIN (-9999) limits are present.
   ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.
   iii. Questionable voltage or flow controlling transformer parameters [TPCH]
   iv. Buses in “islands” not containing a system swing bus [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

8.4 To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.
a. Create a raw data file containing only the area(s) of interest [RAWD, AREA]
b. Read in the raw data file just created [READ]
c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus [CHNG]
d. Locate any islands created by the subsetting operation and either connect or drop them [TREE]
e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in) [BGEN]

9.5 Net generation with load at any buses where a generator(s) exists for which no dynamic models are available [GNET].

10.6 Convert the generators in the load flow [CONG], solve [ORDR, FACT, TYSL] and save converted case [SAVE]

11.7 From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory).
a. Specify CONEC, CONET, and COMPIL files.
b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six
monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

12.8. Concatenate PLECS code for user models onto CONEC or CONET files.
12.9. Compile.
14.11. Restart from the dynamics entry point, this time using “user dynamics”.
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE].
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.
      ii. A tabulation of conditions at each online machine
         a) Terminal voltage
         b) Exciter output voltage
         c) Real and reactive power output
         d) Power factor
         e) Machine angle in degrees
         f) Direct and quadrature axis currents on machine base.
      iii. A diagnosis of initial conditions, either
         a) “Initial conditions check OK”, or
         b) A listing of suspect initial conditions generally states whose time derivative is not “small” (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.
         iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.
      f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.
16.12. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.
17.13. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN, CM] can indicate where problems are, but considerably increases the amount of output.
19.15. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal
voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
a. Excessive overshoot
b. Sustained oscillations
c. High frequency noise (may be caused by using too long a simulation step)
d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 "non-continuous" regulator models).

20.16 Validate governor model response to a step change. [GSTR] and [GRUN].
   Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((-K) = (-1/R)\), mechanical power to \((1-1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Dynamic Data Format
PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

Non-PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC drops, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

Acceptable Dynamic Model Information
The PSS®E simulation software dynamic machine models may be used as long as they are included on the NERC List of Acceptable Models for Interconnection-Wide Modeling and not identified as unacceptable models on that list. The NERC acceptable dynamic model list can be found on the NERC SAMS website → SAMS Reference Materials → NERC Acceptable Model List.

Significant improvements to models may occur over time and models may become obsolete, not recommended, or unacceptable models. Unacceptable models might still be available in the PSS®E software; however, those models must be replaced with more suitable current acceptable models.

User-written dynamic models will only be allowed under the following conditions:
1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
**22.3.** Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes.

**23.4.** Documentation, including Block Diagram, in .pdf or .docx format

**24.5.** A written commitment from the Data Owner to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified of request for conversion to an acceptable model by SPP or Transmission Planner.

MDWG developed a subset list of acceptable dynamic models based on the NERC acceptable dynamic model list and adheres to the guidance outlined in the MDWG Dynamic Models Guidelines document.

### Dynamics Data Validation Requirements

**e.1.** All dynamics modeling data shall be screened according to the SDDB data screening checks.

**25.2.** All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.

**26.3.** All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section II.H* of this manual (*yet to be written) may be applied for this purpose.

### Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).

2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

### Procedures for Submission of Dynamics Data to the MMWG Coordinator

Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

**Dynamics Data Updates Using Excel Template**

Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready. The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.
### Type of Update

<table>
<thead>
<tr>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
</tr>
<tr>
<td>Replace a model with another model of the same equipment group</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes for new model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all models of an existing unit</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
</tr>
<tr>
<td>Change bus number</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
</tr>
</tbody>
</table>

### Complete Set of Dynamics Data

The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

### System Dynamic Data Base and Dynamic Simulation Cases

SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators the positive and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Mutual Impedance

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line. Zero-sequence current is only present during ground faults, so the consideration of mutual coupling effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence Commented [MO1]: Is this accurate?
fault current. It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.\textsuperscript{22}

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSS®E, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSS®E models can be identified by checking when mutual impedance data is modeled and updated in a company's primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

\textbf{Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).} The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the MDWG Powerflow models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

- \textit{27.1. MDWG steady-state base model}
- \textit{28.2. MDWG steady-state with PSS®E Classical assumptions}
- \textit{29.3. Maximum Fault case}

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

\textsuperscript{22} \textbf{NERC Lesson Learned: Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements}
All transformers shall have a Vector Group and corresponding Connection Code in PSS®E 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of the modeled sequence information prior to finalization.

Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.
SECTION 6: DEFINITIONS

These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner** – The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Data Submitter** – The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered a power export and a negative value is considered a power import.

---

23 Not a NERC functional entity
Model Area – The collection of model objects comprising an entity’s network and uniquely numbered in PSS®E.

Peak Demand – The highest demand including transmission losses for energy measured over a one clock hour period.²⁴

PSS®E – Siemens PTI’s Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

PSS®E MOD – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

PSS®MOD File Builder – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS®MOD Modeling projects by comparing PSS®E models.

Transaction (Model) – A modeled purchase and/or sale of power.

Non-scalable load – Load that does not conform to the daily load duration curve.

On-Peak (Model) – Those hours or other periods typically considered periods of higher electrical demand.

Off-Peak (Model) – Those hours or other periods typically considered periods of lower electrical demand.

Regulating device – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

Shortfall – Occurs when an entity does not have enough dispatchable generation to serve the entity’s load.

Tie Line (Model) – A circuit connecting two Model Areas.

²⁴ Attachment AA Resource Adequacy Section 2
SECTION 7: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,
From Area Name,
From Bus#,
From Bus Name,
From Bus kV,
To Region Name,
To Area#,
To Area Name,
To Bus#,
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
GI [pu],
BI [pu],
GJ [pu],
BJ [pu],
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#, 
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#, 
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS {0,1},
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM11,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
Wind V2,
NomV2
Three Winding Transformer Data Fields

- In Service Date,
- Out Service Date,
- Winding 1 Region Name,
- Winding 1 Area#,
- Winding 1 Area Name,
- Winding 1 Bus#,
- Winding 1 Bus Name,
- Winding 1 Bus kV,
- Winding 2 Region Name,
- Winding 2 Area#,
- Winding 2 Area Name,
- Winding 2 Bus#,
- Winding 2 Bus Name,
- Winding 2 Bus kV,
- Winding 3 Region Name,
- Winding 3 Area#,
- Winding 3 Area Name,
- Winding 3 Bus#,
- Winding 3 Bus Name,
- Winding 3 Bus kV,
- CKT,
- CW,
- CZ,
- CM,
- MAG1,
- MAG2,
- NMETR(1,2,3),
- NAME,
- STATUS(0,1),
- Owner 1,
- Fraction 1,
- Owner 2,
- Fraction 2,
- Owner 3,
- Fraction 3,
- Owner 4,
- Fraction 4,
- R1-2,
- X1-2,
- SBase1-2,
- R2-3,
- X2-3,
- SBASE2-3,
- R3-1,
Three Winding Transformer Data Fields - continued

X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
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Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
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Control Bus Name,
Control Bus KV,
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RM11,
VMA1,
VM11,
NTP 1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued
RM12,
VMA2,
VM12,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
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Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
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Control Bus 3 KV,
RMA3,
RM13,
VMA3,
VM13,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields
In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (R,I),
DCVMIN,
CCCTMX,
CCCACC,
IPR REGION NAME,
IPR AREA#,
IPR AREA NAME,
IPR Bus#,
IPR BUS NAME,
IPR BUS Kv,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#,
ICR AREA NAME,
ICR BUS#, 
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#,
IFR AREA NAME,
IFR BUS#, 
IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS #,
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAPR,
IPI REGION NAME,
IPI AREA #,
IPI AREA NAME,
IPI Bus #,
IPI BUS NAME,
IPI BUS KV,
NBI,
GAMMX,
GAMMN,
RCI,
XCI,
EBASI,
TRI,
TAPI,
TMXI,
TMNI,
STPI,
ICI REGION NAME,
ICI AREA #,
ICI AREA NAME,
ICI BUS #,
ICI BUS NAME,
ICI BUS KV,
IFI REGION NAME,
IFI AREA #,
IFI AREA NAME,
IFI BUS #,
IFI BUS NAME,
IFI BUS KV,
ITI REGION NAME,
ITI AREA #,
ITI AREA NAME,
ITI BUS #,
ITI BUS NAME,
ITI BUS KV,
IDI,
XCAPI

Notes:
(1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
## SECTION 8: APPENDIX II

### UTILIZED IMPEDANCE CORRECTION TABLES

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### Table Notes
- The table above lists the utilized impedance correction factors for various tap or angle settings.
- Each row represents a different table number, indicating the specific correction factor for a given tap or angle setting.
- The columns include the tap or angle, table number, and the corresponding factor.
- These tables are essential for accurately correcting the impedance in SPP Model Development Procedure Manual applications.
SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice
Designating MOD-032-1 Data Submittal Assignment

On this ______ day of ______________, 20______, _______________________ and __________________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following:

On ___________________, 20____, _____________________, Data Owner, and _________________, Data Submitter, entered into an agreement through which ______________________ has agreed to submit on behalf of __________________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

__________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________

The accuracy of the data is the responsibility of the Data Owner. This notice does not shift the compliance obligation from the Data Owner to the Data Submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER:    SPP hereby acknowledges receipt of this notice.
By: ______________________________    By: ______________________________
Printed Name: _____________________   Printed Name: _____________________
Title: _____________________________   Title: _____________________________
Date: _________________     Date: _________________

On behalf of DATA SUBMITTER:
By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: ____________
### SPP MOD Project Type/Status Matrix

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<th>Type</th>
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<td>Approved</td>
<td>Description changes that require approval for SPP Transmission System (e.g., changes to the transmissible data or components that may be connected to the SPP Transmission System in accordance with SPP GAU Attachment 5 and AQ processes, as submitted separately under the “Generation Interconnection” or “Attachment AQ Load” MOD Types.)</td>
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<td>SPP-approved</td>
<td>Planned Change of Transmission Systems that does not yet have or does not</td>
<td>Approved</td>
<td>Requires material changes, Data Submitters shall submit an NMB ticket as a way of notifying SPP. The status for this MOD type will only be changed to “Acknowledged” by Data Submitters after receiving a notification that SPP is including in the model sets.</td>
</tr>
<tr>
<td>SPP-approved</td>
<td>Attachment AQ</td>
<td>Acknowledged</td>
<td>Material transmission changes that have been acknowledged by SPP and may be included in model sets. The status for this MOD type will only be changed to “Acknowledged” by Data Submitters after receiving a notification that SPP is including in the model sets.</td>
</tr>
<tr>
<td>SPP-approved</td>
<td>Special Study</td>
<td>Approved</td>
<td>Data Submitters shall submit an NMB ticket as a way of notifying SPP. The status for this MOD type will only be changed to “Acknowledged” by Data Submitters after receiving a notification that SPP is including in the model sets.</td>
</tr>
<tr>
<td>SPP-approved</td>
<td>Generation Interconnection</td>
<td>Approved</td>
<td>Use this MOD Project Type to submit changes to transmission models that may be included in the model sets.</td>
</tr>
<tr>
<td>SPP-approved</td>
<td>Network Status</td>
<td>Update</td>
<td>Projects with this status will be immediately committed to the MOD process and will be placed in out-of-service status.</td>
</tr>
<tr>
<td>SPP-approved</td>
<td>System Status</td>
<td>Update</td>
<td>Projects with this status will not be applied to any models except those models submitted to MMWG.</td>
</tr>
</tbody>
</table>
The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state (Items marked with an asterisk indicate data that vary with system operating state or conditions. These items may have different data provided for different modeling scenarios)</th>
<th>dynamics (If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>a. Positive Sequence Data</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>b. Negative Sequence Data</td>
</tr>
<tr>
<td>Aggregate Demand*[2] [LSE]</td>
<td>4. Power System Stabilizer [GO, RP (for future planned resources only)]</td>
<td>c. Zero Sequence Data</td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td>5. Demand [LSE]</td>
<td>2. Mutual Line Impedance Data [TO]</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td>6. Wind Turbine Data [GO]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>3. Generating Units*[26] [GO, RP (for future planned resources only)]</td>
<td>7. Photovoltaic systems [GO]</td>
<td></td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
<td></td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td>9. DC system models [TO]</td>
<td></td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide</td>
<td>10. Other information requested by the Planning Coordinator or</td>
<td></td>
</tr>
</tbody>
</table>

---

25 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>d.</td>
<td>regulated bus* and voltage set point* (as typically provided by the TOP)</td>
</tr>
<tr>
<td>e.</td>
<td>machine MVA base</td>
</tr>
<tr>
<td>f.</td>
<td>generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
</tr>
<tr>
<td>g.</td>
<td>generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
</tr>
<tr>
<td>h.</td>
<td>in-service status*</td>
</tr>
<tr>
<td>4.</td>
<td>AC Transmission Line or Circuit [TO]</td>
</tr>
<tr>
<td>a.</td>
<td>impedance parameters (positive sequence)</td>
</tr>
<tr>
<td>b.</td>
<td>susceptance (line charging)</td>
</tr>
<tr>
<td>c.</td>
<td>ratings (normal and emergency)*</td>
</tr>
<tr>
<td>d.</td>
<td>in-service status*</td>
</tr>
<tr>
<td>5.</td>
<td>DC Transmission systems [TO]</td>
</tr>
<tr>
<td>6.</td>
<td>Transformer (voltage and phase-shifting) [TO]</td>
</tr>
<tr>
<td>a.</td>
<td>nominal voltages of windings</td>
</tr>
<tr>
<td>b.</td>
<td>impedance(s)</td>
</tr>
<tr>
<td>c.</td>
<td>tap ratios (voltage or phase angle)*</td>
</tr>
<tr>
<td>d.</td>
<td>minimum and maximum tap position limits</td>
</tr>
<tr>
<td>e.</td>
<td>number of tap positions (for both the ULTC and NLTC)</td>
</tr>
<tr>
<td>f.</td>
<td>regulated bus (for voltage regulating transformers)*</td>
</tr>
<tr>
<td>g.</td>
<td>ratings (normal and emergency)*</td>
</tr>
<tr>
<td>h.</td>
<td>in-service status*</td>
</tr>
</tbody>
</table>

Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GD, LSE, TO, TSP]
<table>
<thead>
<tr>
<th>Item</th>
<th>Action Item</th>
<th>Date Originated</th>
<th>Status</th>
<th>Comments/Updates</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>MDWG Power Flow Focus Group to look at MDWG Dispatching Methodology</td>
<td>November 1, 2018</td>
<td>In Progress</td>
<td>MDWG Model Dispatch Group created to address the model improvement effort</td>
<td>Staff and MDWG Model Dispatch Focus Group</td>
</tr>
<tr>
<td>31</td>
<td>Staff to reach out to MISO modeling staff to gather the bus mapping data.</td>
<td>January 9, 2019</td>
<td>In Progress</td>
<td>Under discussion with MISO as part of Action Item #2. Request sent to MISO TOPs. Waiting for data by deadline of Nov 15, 2019. 1/1/2020: Michael said it won't happen in this next iteration but SPP will be coordinating this with MISO directly in the future.</td>
<td>Staff: Michael</td>
</tr>
<tr>
<td>50</td>
<td>MDWG Power Flow Focus Group to develop the shunt device testing plan and work. Staff to bring planning concerns to the power flow focus group.</td>
<td>6-Jun-19</td>
<td>In Progress</td>
<td>MDWG powerFlow focus group determined test plan including a data request template. SPP modeling sent out a data request for shunt modeling on 8/1/2019. Benchmarking will be conducted on the 2020 ITP models. 1/29/2020: The powerflow focus group performed a benchmark of shunt modeling based on the proposed language and will present its findings and recommendation at the April MDWG meeting. Additionally, the results were discussed with other SPP Planning groups to gather any additional feedback on the proposed language.</td>
<td>Staff and MDWG Power Flow Focus Group</td>
</tr>
<tr>
<td>68</td>
<td>Justification for the branch zero sequence impedance ratio criteria and review by the short circuit focus group.</td>
<td>October 22, 2019</td>
<td>In Progress</td>
<td>1/29/2020: Short Circuit Focus Group discussed this and Chris Colson presented a write up for justification but this will stay in progress until accomplished</td>
<td>Staff: Michael &amp; Hugh</td>
</tr>
<tr>
<td>72</td>
<td>Staff to communicate to upper SPP management about collective feedback from the Age and Condition Discussion. Additionally note the summary of the discussion within the TWG report.</td>
<td>January 22, 2020</td>
<td>In Progress</td>
<td>Staff communicated the MDWG feedback to SPP upper management. The feedback was also included in the MDWG report for TWG. Transmission Planning staff preference is to not go back in time for the 2019 ITP constraints. Instead, TWG requested Jay to bring a strawman to proposal for how the data will be used. Staff believes the draft proposal is a more efficient direction forward for this effort.</td>
<td>Staff: Sunny</td>
</tr>
</tbody>
</table>
2020 SERIES POWERFLOW MODEL BUILD UPDATE

TRANSMISSION PLANNING MODELING

MOSES ROTICH - MARCH 19, 2020
OVERVIEW

• Status Update Since 2/7/2020 deadline
• Recommendation
STATUS UPDATE SINCE 2/7/2020

DEADLINE

• Model On Demand (MOD)
  • SPP no longer building models out of MOD
  • Data Submitters can make updates in preparation for the 2021 series model build

• Engineering Data Submission Tool (EDST)
  • Requests sent for Data Submitters to resolve any inconsistencies between MOD and EDST data
    • Have to be resolve to match approved models
  • Tie line updates need to be provided as idevs and also through EDST for MMWG purpose
STATUS UPDATE

SINCE 2/7/2020 DEADLINE

• Report Card
  • Review for accuracy to ensure your participation in the model build is accurate

• Planned Transmission System Changes
  • MOD projects with this type need to also be reported through RMS congruent with the MDWG manual

• Executed Generator Interconnection Agreements
  • SPP will send out requests for any recently executed GIAs in anticipation of 2021 Series model build
STATUS UPDATE STATUS UPDATE SINCE 2/7/2020 DEADLINE

- Health of models
  - 2020 MDWG Pre-Final1 powerflow models posted on 3/3/2020
    - Some outstanding docucode issues
    - Feedback in form of idevs due 3/5/2020
  - 2020 MDWG Pre-Final2 powerflow models posted on 3/9/2020
    - **Modeling (CEII, RSD)** → **MDWG Series** → **Powerflow** → **2020 Series** → **H. Pre-Final2**
    - Built using feedback from pre-final1 models
    - Feedback to address outstanding docucode issues, in the form of idevs due 3/16/2020
    - MDWG approval on 3/19/2020
RECOMMENDATION

• SPP staff will recommend that the 2020 MDWG powerflow models be approved by the Model Development Working Group with the caveat that all significant docucode issues (Raw Read Errors, Branch Overloads, Voltage Violations, Pgens Out of Range) are addressed.

• **Motion:** 2020 MDWG Powerflow models be approved with the expectation that all significant docucode issues (Raw Read Errors, Branch Overloads, Voltage Violations, Pgens Out of Range) are addressed.
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. Staff (Lottie Richardson) to send out meeting notification for the Generation Dispatch Focus Group meeting.

2. Staff (Michael Odom) post final MDWG short circuit models within a week.

3. Staff to explore planned retirement data collection improvements to accommodate refueling.

Motions:

1. Motion: Jason Shook motioned to adopt the agenda as modified. Jerad Ethridge seconded the motion. The motion passed unanimously.

2. Andy Berg made a motion to approve the short circuit models with the edited recommendation presented on the screen. Joe seconded it. The motion passed unanimously.
MDWG MINUTES
March 27, 2020

SOUTHWEST POWER POOL
MODEL DEVELOPMENT WORKING GROUP MEETING

March 27, 2020 9:00 am – 12:00 pm (CST)
Conference Call

MINUTES

AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

SPP MDWG Chair, Nate Morris, called the meeting to order at 9:33 am with Quorum. SPP Staff Secrectary, Sunny Raheem, read the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES

The following members attended or represented by proxy:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nate Morris</td>
<td>YES</td>
<td></td>
<td>Empire District Electric Company, MDWG Chair</td>
</tr>
<tr>
<td>Jerad Ethridge</td>
<td>YES</td>
<td></td>
<td>Oklahoma Gas &amp; Electric, MDWG Vice-Chair</td>
</tr>
<tr>
<td>Charles Aleman</td>
<td>YES</td>
<td></td>
<td>Golden Spread Electric Cooperative</td>
</tr>
<tr>
<td>Andrew Berg</td>
<td>YES</td>
<td></td>
<td>Missouri River Energy Services</td>
</tr>
<tr>
<td>Preston Blinsky</td>
<td>YES</td>
<td></td>
<td>Basin Electric Power Cooperative</td>
</tr>
<tr>
<td>John Boshears</td>
<td>No</td>
<td>Jerry Bradshaw</td>
<td>YES</td>
</tr>
<tr>
<td>Joe Fultz</td>
<td>YES</td>
<td></td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Jeremy Harris</td>
<td>YES</td>
<td></td>
<td>KCP&amp;L and Westar, Evergy Companies</td>
</tr>
<tr>
<td>Jason Hofer</td>
<td>YES</td>
<td></td>
<td>Nebraska Public Power District</td>
</tr>
<tr>
<td>Steve Hohman</td>
<td>YES</td>
<td></td>
<td>Omaha Public Power District</td>
</tr>
<tr>
<td>Holli Krizek</td>
<td>YES</td>
<td></td>
<td>Western Area Power Administration</td>
</tr>
<tr>
<td>Jordan Lamb</td>
<td>NO</td>
<td></td>
<td>East River Electric Power Cooperative</td>
</tr>
<tr>
<td>Reené Miranda</td>
<td>YES</td>
<td></td>
<td>Southwestern Public Service</td>
</tr>
<tr>
<td>Alex Mucha</td>
<td>YES</td>
<td></td>
<td>Oklahoma Municipal Power Authority</td>
</tr>
<tr>
<td>Scott Rainbolt</td>
<td>YES</td>
<td></td>
<td>American Electric Power</td>
</tr>
<tr>
<td>Scott Schichtl</td>
<td>NO</td>
<td>Josh Hesselbein</td>
<td>YES</td>
</tr>
<tr>
<td>Jason Shook</td>
<td>YES</td>
<td></td>
<td>GDS Associates</td>
</tr>
<tr>
<td>Liam Stringham</td>
<td>YES</td>
<td></td>
<td>Sunflower Electric Power Corporation</td>
</tr>
<tr>
<td>Sunny Raheem</td>
<td>YES</td>
<td></td>
<td>Southwest Power Pool, Inc., MDWG Secretary</td>
</tr>
</tbody>
</table>
### Additional Guests:

<table>
<thead>
<tr>
<th>Guests</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Josh Hesselbein</td>
<td>Arkansas Electric Cooperative Corporation</td>
</tr>
<tr>
<td>David Zhong</td>
<td>American Electric Power</td>
</tr>
<tr>
<td>Conner Sweet, Jerry Bradshaw</td>
<td>City Utilities of Springfield</td>
</tr>
<tr>
<td>Jeff Crites</td>
<td>Empire District Electric Company</td>
</tr>
<tr>
<td>Cristina Ortiz, Lafayette Gatewood, Ryan</td>
<td>Evergy Companies</td>
</tr>
<tr>
<td>Baysinger</td>
<td></td>
</tr>
<tr>
<td>Dona Parks</td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Michael Wegner</td>
<td>ITC Transco</td>
</tr>
<tr>
<td>Edin Terzic</td>
<td>Lincoln Electric System</td>
</tr>
<tr>
<td>Ryan Benton</td>
<td>Midwest Energy</td>
</tr>
<tr>
<td>Armin Sehic</td>
<td>Municipal Energy Agency of Nebraska</td>
</tr>
<tr>
<td>Daryl Huslig</td>
<td>Oklahoma Gas and Electric</td>
</tr>
<tr>
<td>Eddie Watson, Hugh Benfer, Jeff McDiarmid,</td>
<td>Southwest Power Pool, Inc.</td>
</tr>
<tr>
<td>Kimberly Woods, Lottie Richardson, Michael</td>
<td></td>
</tr>
<tr>
<td>Odom, Moses Rotich, Shahrokh Akhlaghi, Sherri</td>
<td></td>
</tr>
<tr>
<td>Maxey, Zach Sabey</td>
<td></td>
</tr>
<tr>
<td>Dave Sargent, Scott Mijin</td>
<td>Southwest Power Administration</td>
</tr>
<tr>
<td>Hummad Malhi, Joe Williams, Josh Turner</td>
<td>Western Farmers Electric Cooperative</td>
</tr>
<tr>
<td>Ben Hammer, Brianna Haug,</td>
<td>Western Area Power Administration</td>
</tr>
</tbody>
</table>
AGENDA ITEM 1E – AGENDA REVIEW

Nate Morris asked the group if they had a chance to review the agenda and if the group has any modifications to the agenda. Sunny Raheem mentioned that the dispatch focus group meeting is currently being schedule. The group did not voice any additional modifications.

Motion: Jason Shook motioned to adopt the agenda as modified. Jerad Ethridge seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Action Item: Staff (Lottie Richardson) to send out meeting notification for the Generation Dispatch Focus Group meeting.

Material: MAR27_Attach1 - 1e. MDWG Meeting Agenda 20200327_redline.docx

AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Sunny Raheem requested Moses Rotich provide an update on the recent action items. Moses presented and commented on recently completed action items 78 through 80. Moses mentioned he would update the comments section of the new action items in preparation for the April MDWG meeting.

AGENDA ITEM 3 – 2020 SERIES MDWG SHORT CIRCUIT MODELS (APPROVAL ITEM*)

Michael Odom presented the status of the short circuit models. Michael outlined the project updates including internal data submitters and external to SPP data updates provided since the 2/7/2020 deadline. Michael provided the SPP recommendation for the model approval.

The group discussed how the SPP planned retirement list was applied to model updates. OPPD mentioned they have some units that have retired from one fuel and refueled to a different type and those units seem to be considered retired in the models. Michael mention he could accommodate the change to turn those units on as post processing idev corrections. Eddie Watson commented that the units could be treated as outages and not retirements in those particular scenarios. Steve Hohman clarified that the retirement date is from December - January that is a very short time. Steve commented that the units should not be modeled as out of service in the max fault cases.

Jason Shook asked if staff is requesting the group to approve the previously posted models as the final models or the approve models with the intent that updates will be applied to make the models final. Sunny Raheem mentioned he thought the group could follow the same process as the MDWG powerflow model approvals. Sunny asked Moses Rotich to describe to the group about how the group facilitated the changes in the MDWG powerflow approval. Moses mentioned that any changes received between the posting of the powerflow models and the
approval vote were applied to the models and posted as final. Any updates received after the posted final were treated as post processing idevs. Andy Berg voiced support for the similar approach for the short circuit approval. Jared Ethridge proposed an update cutoff of Monday March 30 at 9:00am for members to provide updates to be applied to the posted final models. SPP would post the final models to GlobalScape. Most members supported the similar approval approach with an update cutoff date. The group discussed what types of upgrades should be considered from now to the cutoff date. The group decided to limit the upgrades to connection code, vector group, machine status, and impedance/seq only.

**Motion:** Andy Berg made a motion to approve the short circuit models with the edited recommendation presented on the screen. Joe seconded it. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

Material: MAR27_Attach2 - 3. 2020 MDWG Short Circuit Model Build Update-03272020.pptx

Background Materials Slide 4 Motion Recommendation Language:

- SPP staff recommends the 2020 MDWG short circuit models be approved by the Model Development Working Group with idevs provided by Monday March 30, 2020 by 9am CDT applied to the models.
  - Idev changes limited to connection code, vector group, machine status, impedance/seq only.
  - Significant updates such as topology updates can be considered under post processing idevs.

Sunny Raheem thanked the Data Submitters, MDWG, and staff for the work well done in meeting the schedule deadlines even with the consideration of different roadblocks along the way. Eddie Watson and Nate Morris echoed additional kudos to the group.

**Action Item:** Staff (Michael Odom) post final MDWG short circuit models within a week.

**Action Item:** Staff to explore planned retirement data collection improvements to accommodate refueling.

**AGENDA ITEM 4 – ITP QUARTERLY UPDATE**

Sherri Maxey presented the 2020 ITP and 2021 ITP quarterly update. Sherri provided the 2021 ITP base reliability model entity report card results. The group did not voice any concerns or questions about the update.

Material: MAR27_Attach3 - 4. ITP Quarterly Report_Apr2020.pptx
AGENDA ITEM 5 – SUMMARY OF ACTION ITEMS

1. Staff (Lottie Richardson) to send out meeting notification for the Generation Dispatch Focus Group meeting.

2. Staff (Michael Odom) post final MDWG short circuit models within a week.

3. Staff to explore planned retirement data collection improvements to accommodate refueling.

AGENDA ITEM 6 – DISCUSSION OF FUTURE MEETINGS

Nate Morris outlined the future MDWG, MDWG workshop, MDWG focus groups, and MDWG manual task force meetings

AGENDA ITEM 7 – ADJOURN (APPROVAL ITEM)

Nate Morris asked the group if they had any other topics for discussion before the group adjourned. The group did not voice any additional topics. Moses reminded the group to upload any changes they are submitting as corrections/updates, into MOD and EDST as well in preparation for next model build. Moses will be coordinating with MOD base case submissions with Data Submitters to review and inform SPP on whether they can be committed or not.

**Motion:** Reene motioned to adjourn the meeting. Andy Berg seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at 9:56 am (CDT).

Respectfully Submitted,

Sunny Raheem

Secretary
MDWG MINUTES
March 27, 2020

Attachments

Material: MAR27_Attach1 - 1e. MDWG Meeting Agenda 20200327_redline.docx

Material: MAR27_Attach2 - 3. 2020 MDWG Short Circuit Model Build Update-03272020.pptx

Material: MAR27_Attach3 - 4. ITP Quarterly Report_Apr2020.pptx
AGENDA

1. Administrative Items.................................................................Nate Morris (10 mins)
   a. Call to Order
   b. Antitrust Statement
   c. Attendance
   d. Proxies
   e. Agenda Review (Approval Item)
      i. Acknowledgement of discuss meeting materials
2. Review of Past Action Items.......................................................Sunny Raheem (5 mins)
3. 2020 series MDWG Short Circuit Models (Approval Item*)........Michael Odom /All (60 mins)
4. ITP Quarterly Update.....................................................................................................................Sherri Maxey (15 mins)
5. Summary of Action Items........................................................Sunny Raheem (5 mins)
6. Discussion of Future Meetings**.....................................................Nate Morris (10 mins)
   a. MDWG: April 16, 2020 Conference Call (9:00AM – 12:00PM)
   b. Manual Task Force: April 9, 2020 (10:00AM-12:00PM)
   c. Focus Groups Meetings:
      i. Power Flow: April 6, 2020 (9:30AM – 11:30AM)
      ii. Short Circuit: May 12, 2020 (9:00AM – 11:00AM)
      iii. Dynamics: April 22, 2020 (10:00AM – 12:00PM)
      iv. Generation Dispatch: March 24Scheduling for April 28, 2020 (2:00PM – 4:00PM)
7. Adjourn (Approval Item).................................................................All

* The approval items denoted with “*” shall be jointly developed by PC, TP, and MDWG

** Future meeting times are in central daylight savings.

Antitrust: SPP strictly prohibits use of participation in SPP activities as a forum for engaging in practices or communications that violate the antitrust laws. Please avoid discussion of topics or behavior that would result in anti-competitive behavior, including but not limited to, agreements between or among competitors regarding prices, bid and offer practices, availability of service, product design, terms of sale, division of markets, allocation of customers or any other activity that might unreasonably restrain competition.
OVERVIEW

• Status Update Since 2/7/2020 deadline
• Recommendation
STATUS UPDATE SINCE 2/7/2020

DEADLINE

• Model Updates
  • Data Submitters have submitted updates through the day of final model posting
  • Applying all applicable model updates received for the MDWG powerflow models through March 20, 2020

• External Data Entities
  • Requested MISO TO/TP data for the first time in the Short Circuit model build
  • After initially merging topology updates, there were a large number of additions and removals of facilities internal and external to SPP
  • Decision was made to start with the base MDWG powerflow models and apply only the sequence data updates from the external entities to avoid false topology updates
RECOMMENDATION

• SPP staff recommends the 2020 MDWG short circuit models be approved by the Model Development Working Group with idevs provided by Monday March 30, 2020 by 9am CDT applied to the models.

• Idev changes limited to connection code, vector group, machine status, impedance/seq only.

• Significant updates such as topology updates can be considered under post processing idevs.
ITP QUARTERLY REPORT

SHERRI MAXEY

MARCH 27, 2020
## STATUS LEGEND

<table>
<thead>
<tr>
<th>Status Indicator</th>
<th>Status</th>
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<td>★</td>
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<td>Completed on-time or per rebaseline</td>
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<td>○</td>
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2020 ITP
## COMPLETED MILESTONES

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<th>Previous End Date</th>
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</table>

*In mitigation; project end date is currently at low risk*
mitigation and go green plan

• Ongoing attention to evaluating resource needs and areas where staff can gain efficiencies

• Acceleration of staff solution development based upon similar issues observed in 2019 ITP
  • Internal staff training to prepare for solutions development and evaluation, and to gain bench strength

• Improvements for DPP submittal tracking and technical validation
  • Submittal form updates including a “self-validating” button
  • DPP Educational Session held to help educate stakeholders and improve quality of submittals

• Targeted automation enhancements for previously manual tasks
DEPENDENCIES/RISKS

• TWG/ESWG approval needed for schedule rebaseline at April meetings
• Schedule revisions considered are dependent upon the development of staff solutions during the DPP Window and beginning DPP technical validation as soon as possible
  • Beneficial if DPPs are received prior to end of DPP Window for staff validation
• Schedule estimates based on receiving 1,200 DPPs; if a greater number is received, may need to re-evaluate schedule
• Reduced staff analysis time
• Internal network run issues causing failures
• Uncertainty around timing for 2020 ITP Target Area and coordination on ITP Coordinated System Plan (CSP) efforts with MISO
2021 ITP
### COMPLETED MILESTONES

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<th>Milestone</th>
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## CURRENT AND UPCOMING MILESTONES

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* Scope approved at Jan. MOPC pending finalization of Consolidation section at Jul. 2020 MOPC; Apr. MOPC review
Essentially all Data Submitters that participated in the model build submitted data by the scheduled deadline; however, additional corrections were submitted after the deadline by the following entities:

<table>
<thead>
<tr>
<th>Applicable Entities</th>
</tr>
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<tbody>
<tr>
<td>Nextera</td>
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Note: SPP performed evaluations of all late requests/changes per Section 10.3 of the SPP ITP Manual.
## REVISION HISTORY

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<th>AUTHOR</th>
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the
development of Near-term and Long-term Transmission Planning Horizon models necessary to
support analysis of the capability, reliability, and suitability of the SPP Transmission System. This
section describes the applicability of entities, Data Owners, equipment, and Data Submitters to
which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s
planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each
of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org.
Additionally, the schedule for submission of data and the list of MDWG models (case
types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for
model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases)
that include a reasonable projection of the anticipated transmission system conditions as will be
operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability
Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission
Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability
planning and compliance assessments. In addition, the base cases are developed in support of
various SPP planning processes in accordance with SPP model data and reporting procedures that
include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic
disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC
by applicable Data Submitters, meant to represent the transmission system in the SPP region in a
steady-state, system-intact condition. The system topology, generator dispatch, and system loads
modeled in the base cases are intended to be respective and representative of the projected
transmission system as will be operated within the SPP footprint under reasonably anticipated
weather and time-of-day conditions for the year and season being represented in each base case.
Reasonable projections within each case include all firm generator commitments, forecasted load
commitments, firm interchange commitments, expected transmission topology and expected
seasonal transmission or generation outages. Additionally, base cases may include reasonable
system projections based on details specified in later sections of this document and based on
historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon
accurate and comprehensive data collection, review, and compilation. The SPP Model Development
Working Group recognizes that to properly develop SPP Transmission System models, a constituency
of responsible entities must collaborate in the model building effort. The transmission system
subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP
Transmission System models. Therefore, consistent with both the applicability of the NERC Data for
Power System Modeling and Analysis Reliability Standard (MOD-032-1)1, and the provisions of the

1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶
61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

---

\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

**Applicable Data Submitters**

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

A completed Letter of Notice identifying responsibilities between a Data Owner and a Data Submitter is required to be submitted to SPP. This Letter of Notice is included in the appendix section.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

---

4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
**Applicable Equipment**

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the Bulk Electric System (BES).
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

Accountability

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and DataSubmitter awareness during the model-building process:

- Appropriate lead times. Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.
- An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes. In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format
PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

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<td>Annual + 1 Fall Peak</td>
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<td>Annual Summer Peak</td>
<td>Annual + 1 Winter Peak</td>
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<tr>
<td>Annual Fall Peak</td>
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</tr>
<tr>
<td>Annual + 1 Spring Peak</td>
<td>Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 Summer Shoulder</td>
<td>Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models...
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

**Data Transmittal**
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- [GlobalScape](#)
2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the "SPP MDWG File Sharing Site", [GlobalScape](#). Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP Model Release Guidelines**
**Steady-State and Short Circuit Models**
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.

**SPP Model Contact:**
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

**Request an SPP Map / Model**
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

**Last Updated July 26, 2018**

**MMWG Deliverables**

**Regional Coordinators**
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

**MMWG Coordinator(s)**
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   a. Initialized steady state and regional contingency cases.
   b. Steady-State RAWD case file
   c. Conversion IDEV files

2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

**System Abbreviations & Area Number Assignments**
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

**MDWG Contact List**
The MDWG Contact List can be found on SPP's GlobalScape under Modeling (CEII, RSD) → SPP Modeling Contacts → 3. Final Modeling Contacts

**NOTE** – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

**Compliance**

1. MDWG Model Development Procedure Manual  
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list  
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)  
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

**Engineering Data Submission Tool**

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. **Transactions** – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. **Generators** – Required generator data that is not otherwise captured in the models including but not limited to the generator type, long name, and associated Auxiliary load.
3. **SPP Modeling Assignments** – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. **Load Details** – Identify loads not served by native model areas.
5. **Bus Details** – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. **Interregional Ties** – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. **Outages** – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts that meet TPL-001 requirements shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be not coincident to the SPP region, meaning that the hour that a Data Submitter's system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast. A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such
location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have an updated service agreement, or are in the process of finalizing a service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS® idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Not Coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

On-Peak/Off-Peak Models

Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority Coincident Peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
</tbody>
</table>

Typically 70% - 80% of Summer On-Peak load level

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.
Load Data
Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the EDST.

Area Summary Report
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**

Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member **must** coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**

Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The "from bus," "to bus," and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The "from bus" is assumed to be the metered end (unless the "to bus" is entered with a negative) and the "to bus" area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the "from bus" or first bus number after the change code. The "from bus" is the metered end unless the "to bus" or second bus number is a negative number. Remember to include the circuit identifier.
3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional.

6. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

7. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

Bus Data
For all SPP steady-state models, systems will model buses within their SPP allocated bus range. [see Section 6-B]. For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. All bus shunts will be modeled as switched shunt. The Switch Shunt may be locked. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine what action(s) are taken with the data supplied (addition, deletion, modification, etc...).
NOTE: When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Below 69 kV</td>
<td>1</td>
</tr>
<tr>
<td>69 kV - 138 kV</td>
<td>2</td>
</tr>
<tr>
<td>138 kV - 345 kV</td>
<td>4</td>
</tr>
<tr>
<td>230 kV - 500 kV</td>
<td>5</td>
</tr>
<tr>
<td>345 kV - 500 kV</td>
<td>7</td>
</tr>
<tr>
<td>500 kV - 765 kV</td>
<td>8</td>
</tr>
<tr>
<td>765 kV or above</td>
<td>9</td>
</tr>
</tbody>
</table>

1. For generator regulated buses, a desired voltage set point will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the Station Service or Auxiliary load. The practice of using generator for voltage support only (i.e., no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.

Do not model existing or planned shunts on the Bus record. Shunts should be modeled in the Switched Shunt Record unless they are line shunts and trip when the line is opened. Bus shunt voltage bandwidth must be wide enough to prevent “hunting” of shunt value during steady-state solution of base case or contingency analysis. The switched shunts can be modeled as fixed shunts with specified B initial value.
SHUNT DATA

Shunt reactive devices are key components used, in conjunction with generating unit excitation, to regulate transmission system voltage, as well as facilitate operating flexibility while assisting to maximize transmission capacity. Shunt reactive devices are typically characterized as either static or dynamic, based upon their responsiveness to system voltage variations.

Static reactive devices tend to respond more slowly, either through automatic or manual switching according to a broader voltage schedule or range of system voltage conditions. Dynamic reactive devices tend to respond very quickly, automatically adjusting their reactive contributions to the system so as to maintain a voltage set point (Regulating device). The four primary static and dynamic reactive device categories are:

- **Fixed shunt device (Locally-switchable static devices)** - Typically require a switchman to physically close a switch in the field under de-energized conditions. These devices require human interaction at the location of the device in order to change the status and are not self-switching. These devices should be represented as fixed shunt devices in software simulations.

- **Switched Shunt, Locked mode (Remotely-switchable static devices)** – Can be placed in, or taken out of, service by a System Operator remotely operating a switch from a Control Center. These devices require human interaction in order to change the status, are not self-switching, are not used for automatic system adjustments, but are used for manual system adjustments (regulating device). These devices should be represented as switched shunt devices in locked mode (0) in software simulations and set to their expected seasonal Mvar (Binit) values.

- **Switched Shunt, Discrete mode (Automatically-switchable static devices)** – Can be placed in, or taken out of, service by an automatic controller (e.g., the Protection System) that actuate powered switch closures. These devices are self-switching, are used for automatic system adjustments (regulating device), but not used for manual system adjustments. These devices should be represented as switched shunt devices in a discrete switching mode (1, 3, 4, 5, or 6) in software simulations.

- **Switched Shunt, Continuous mode (Automatically-switchable dynamic devices)** – Reactive contribution is adjusted by an automatic controller. These devices are used for automatic system adjustments (regulating device), but not used for manual system adjustments. Examples of dynamic reactive devices include: static VAR compensators (SVC), static compensators (STATCOM), and direct current voltage source converters (VSC). These devices should be represented as switched shunt devices in a continuous switching mode (2) in software simulations.

Load flow software offers multiple options for modeling shunt reactive devices and care must be used when selecting the appropriate representation. The primary modeling capability considerations for non-rotating mass reactive devices are:

- **Shunt implementation: fixed, or switched.**
• Simulated control mode: Locked, discrete, or continuous.
• Regulated voltage band limits: high \((V_{hi})\) and low \((V_{lo})\).

Upon selecting the appropriate modeling representation for the non-rotating mass shunt reactive device, the Data Owners/Data Submitter shall ensure that the following is entered for:

Non-regulating shunt capacitor or reactor device (static, locally-switchable device)

• Fixed shunt (no control mode) with a unique shunt ID.
• Total reactive device admittance \(11\) (MW and MVAR) that represents the aggregated contribution of the reactive banks or blocks installed as a fixed device.
• In-service status, set to zero \((0)\) if the device is not in-service.

Regulating shunt devices

• Switched shunt with 'SW' shunt ID (forced by software).
• Total reactive device admittance \(12\) (MVAR only), differentiated into quantities of admittance that represent the installed controllable device reactive banks or blocks, as appropriate.
• Regulated voltage band limits, either as a schedule \((V_{hi} \neq V_{lo})\) for static reactive devices or as a set point \((V_{hi} = V_{lo})\) for dynamic reactive devices, appropriate to the equipment.
• Reactive limits, for dynamic reactive devices only.
• Control mode-of-operation, as listed above:
  o Static, remotely-switchable device – locked, control mode \((0)\).
  o Static, automatically-switchable device - unlocked, discrete control modes \((1, 3, 4, 5,\) or \(6)\).
  o Dynamic device – unlocked, continuous control mode \((2)\).
• Assignment of the regulated bus, for switched shunt representations only.
• In-service status, set to zero \((0)\) if the device is not in-service.

The Data Owners/Data Submitter should consider the load flow numerical solution stability implications of the regulated voltage band limits \((V_{hi}, V_{lo})\) when entering data for the shunt reactive devices. The ability of the load flow numerical solver to derive an acceptable voltage state may be impeded by a switched shunt with a discrete control mode whose reactive contribution, when switched, pushes the voltage of its connected bus outside of convergence tolerances. Therefore, a limit difference of less than 0.025 pu shall not be used when entering the regulated voltage band limits \((V_{hi}, V_{lo})\) for a switched shunt reactive device. Similarly, switched shunts shall not be connected to generator buses or to a generator bus through a zero-impedance branch.

All shunt reactive devices attached at transmission-level buses (i.e., 60 kV or greater) or attached to the tertiary of a transmission-level power transformer shall be modeled explicitly and not as loads or aggregated with loads. Further, static reactive devices connected to transmission lines are known as line shunts. The PSS®E load flow software allows line shunts to be modeled as part of the BRANCH data record. An alternative approach is to model the line shunt explicitly by using an intermediate

\[11\] Shunt conductance and susceptance quantities are entered in units of MW and MVAR representing the total per-unit admittance at rated voltage, on system base MVA.

\[12\] Shunt susceptance quantities (conductance is assumed to be zero) are entered in units of MVAR representing the total per-unit admittance at rated voltage, on system base MVA.
bus and zero-impedance branch (ZBR), as shown in Figure 1, even when the line shunt is locally-switchable only and expected to match the in-service status of the connected branch. In this scenario, losing the transmission line, but not the line shunt, can cause low voltage conditions that may not be realistic.

The Data Owner/Data Submitter must remember that the switched shunt reactive device control mode employed by the load flow software offers significantly more flexibility than shunt reactive devices implemented in the transmission system. Care should be taken to best represent the actual operation of installed shunt reactive devices and not allow unlocked control modes when inappropriate. During the model build process, similar to the process of case conditioning prior to analysis, remotely-switchable devices may be unlocked and automatically-switchable devices may be locked, expressly for the purpose of obtaining a converged load flow solution. However, care must be taken to ensure that the final state of the model contains the correct control mode, including locking, appropriate to the shunt reactive devices represented. The Data Owners/Data Submitters should also consider individual device protection settings as they relate to voltage control mode and limits.
Generator Data
Generating unit MW and MVAR output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits with consideration of MOD-025-2 and SPP Planning Criteria 7.1.1., or company-specific procedure for testing the gross capability of the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with Auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities.

For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to XSOURCE Table.

For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour.

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance information is provided.

When modeling mothballed and future retired units, the unit will be modeled offline (in-service status = 0). The capability amounts for PMAX, PMIN, QMAX, and QMIN should not be changed until the unit is fully decommissioned similar to units that are not dispatched in the particular seasonal model. Unit retirement information will be provided in a separate document and posted through a secure website. Decommissioned units should be removed from the models.

Modeling Process for Generator Parameters
a. The Generator parameter PMAX shall be modeled as a gross seasonal maximum capability based on SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.
b. Generating plant Station Service load and Auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All Station Service load and Auxiliary load representations shall:

i. Be modeled explicitly on the appropriate bus corresponding to the voltage to which the Auxiliary load is served. Model representations of Auxiliary load connected to the generating unit bus (Figure VII-1), Auxiliary load modeled with separate transformation (Figure VII-2), and Auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.

ii. Be annotated as non-scalable.

![Diagram](image)

![Diagram](image)

![Diagram](image)

Figure VII-1. Common bus representation
Figure VII-2. Separate transformation representation
Figure VII-3. Transformer high-side representation

Experience has shown that generating plant Station Service load and Auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant Station Service load and Auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable Station Service load and Auxiliary load.

If generating plant Station Service load and Auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant Station Service load and Auxiliary load shall use “Sn” in the Load ID for one or more aggregated generating plant Station Service loads (Figure VII-4a).

If generating plant Station Service load and Auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant Station Service load and Auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b).

13 Station Service load and Auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant Auxiliary load.
VII-4b. The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “F<sub>n</sub>” in the Load ID field<sup>14</sup> to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “V<sub>n</sub>” in the Load ID field<sup>14</sup> to designate variable load quantities that do vary with plant dispatch.

Aggregated Auxiliary Load “Sn”

- Combined Auxiliary Load (Fixed portion) “F1”
- Combined Auxiliary Load (Variable portion) “V1”

Discrete Station Heater Auxiliary Load (Fixed) “F2”
Discrete Fuel Auger Auxiliary Load (Variable) “V2”
Discrete Station Lighting Auxiliary Load (Fixed) “F3”
Discrete Effluent Pump Auxiliary Load (Variable) “V3”

Figure VII-4. Examples of generating plant Auxiliary load representations (aggregated, combined, and discrete).

Only generating plant Station Service load or Auxiliary load IDs should be labeled with “S<sub>n</sub>”, “F<sub>n</sub>”, or “V<sub>n</sub>”; all other load types should be labeled differently.

Generating plant Station Service load or Auxiliary load IDs of “S<sub>n</sub>” or “V<sub>n</sub>” should be modeled such that the in-service status of the load follows the in-service status of the generator in which it is connected. For example: Generator 1 is offline, then the associated generating plant Station Service load or Auxiliary load with load IDs of “S<sub>n</sub>” or “V<sub>n</sub>” should also be offline.

Station Service or Auxiliary load modeling should be done in accordance with the state of the generator as follows:

<table>
<thead>
<tr>
<th>Generator State</th>
<th>Aggregated “Sn” SS or Aux Load</th>
<th>Variable “Vn” SS or Aux Load</th>
<th>Fixed “Fn” SS or Aux Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>In-Service</td>
<td>In-Service</td>
<td>In-Service</td>
</tr>
<tr>
<td>Offline</td>
<td>In-Service</td>
<td>Offline</td>
<td>In-Service</td>
</tr>
<tr>
<td>Decommissioned</td>
<td>Removed from model</td>
<td>Removed from model</td>
<td>Removed from model</td>
</tr>
</tbody>
</table>

Aggregated Station Service or Auxiliary loads shall be updated to reflect the dispatch of the associated generator.

The Generator Parameters for PMIN, AUX Load, QMAX, and QMIN shall be modeled in accordance with MOD-025-02 and SPP Planning Criteria 7.1 testing and reporting procedures.

Modeling of Wind/Solar Renewable Resources P<sub>GEN</sub>

<sup>14</sup>“n” represents a unique numeric value. PSS/E/PSS®E requires each load placed at a bus to have a unique Load ID.
• Spring Light Load Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP minimum load hour corresponding to the season of the Light Load case, not to exceed each facility’s firm service amount. The methodology used to calculate replacement data is described in the ITP Manual. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

• On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident peak, not to exceed each facility’s firm service amount.

• SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build. Any renewable resource modeling data submitted to the PC, after the initial dispatch list is provided, will be dispatched at the seasonal state dispatch percentage of the renewable resource’s nameplate amount.

• When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

• Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

• For resources that do not have firm service, $P_{GEN}$ values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

Shortfall Guidance Process
Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   a. The in-service date shall be based on the expected in-service date of the GI study.
   b. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®/E).

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15 SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future Exploratory Generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future Exploratory Generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, Exploratory Generation should be based upon the host TO Resource Plan.
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
   d. The addition of Exploratory Generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

**EXTERNAL RESOURCE MODELING**

**Purpose**
This procedure assures that members adhere to a uniform process when modeling external resources in SPP.

**Modeling Process**
If a member acquires external resources outside their Model Area, the following modeling process should be followed:

1. All buses should be assigned numbers that are in the host’s Model Area bus number range.
2. Area Number/Name should be the host’s Model Area number.
3. Zone Number/Name should be in the host’s Model Area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

**Owner Data and Line Mileage Data (SSAE Control)**

To meet the Statement on Standards for Attestation Engagement (SSAE) requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The [MMWG Procedure Manual](#) contains information related to the following:

1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

**Initial Run Review**

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.
1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
   Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
   The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.
a. Voltage Summaries

Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated.
A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. Summary of Overloaded Branches

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. Generation Summary

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.
The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. $Q_T \rightarrow \text{MAX} = \text{one-half of MW rating}$

ii. $Q_B \rightarrow \text{MIN} = \text{negative one-third of MW rating}$

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-buil representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc…) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure to update MOD.
2. Submitting a PTI IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data
for that bus will be removed (e.g., branches, transformers, generators, and loads). The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified. Data currently in the model is used as the default value for data fields not specified in the format.

Steady-State Solution

The steady-state solution will have "Area interchange control" with the "Tie Line and Loads" option selected to meet ERAG MMWG model building requirements.

Error Screening

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
6. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

STEADY-STATE MODELING REQUIREMENTS

GENERATORS

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-
state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the XSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

**XSOURCE Table:**

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS FOR XSOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous:</td>
<td>Unsaturated sub-transient reactance ($X''_d$) [PU]</td>
</tr>
<tr>
<td>Detailed</td>
<td>Subtransient</td>
</tr>
<tr>
<td>Synchronous:</td>
<td>Unsaturated transient reactance ($X'_d$) [PU]</td>
</tr>
<tr>
<td>Non-Detailed</td>
<td>Classical or Transient</td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated transient reactance ($X'_d$) of single machine [PU*]</td>
</tr>
<tr>
<td>Wind Type 1</td>
<td>OR</td>
</tr>
<tr>
<td>Wind Type 2</td>
<td>Locked rotor reactance (sum of rotor and stator leakage reactances) [PU]</td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated transient reactance ($X'_d$) of single machine [PU]</td>
</tr>
<tr>
<td>Wind Type 3</td>
<td>Wind Type 4</td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated sub-transient reactance ($X''_d$) [PU]</td>
</tr>
<tr>
<td>Inverter-Based Solar PV</td>
<td></td>
</tr>
<tr>
<td>Wind Type 4</td>
<td>$V_{rated} = \text{Rated Voltage} = 1.0 \ [\text{PU}]$ (assumed)</td>
</tr>
<tr>
<td></td>
<td>$I_{rated} = \text{Rated Current From GO} \ [\text{PU}]$</td>
</tr>
<tr>
<td></td>
<td>$X_{source} = \frac{V_{rated}}{I_{rated}} \ [\text{PU}]$</td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated sub-transient reactance ($X''_d$) [PU]</td>
</tr>
<tr>
<td>Wind Type 5</td>
<td>Wind Type 5</td>
</tr>
</tbody>
</table>

* PU values should be based on the rated terminal voltage and machine MVA base

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation. If a user model representing particular SVC
and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:
   a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used
   b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation
   c. Different development phases
      i. These representations should be combined as the phases are placed in service as applicable

OTHER DEVICES

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 118.05, 110, 72, and 63.5 kV. Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

   If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model
bus ties using $R=0.00000 + X=0.0001$ and $B=0.00000$. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of $R=0.0001 + X=0.002$ and $B=0.00000$. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – To adequately model transformers, the following parameters, at a minimum, are required:
   a. Nominal voltage of windings and bus reference to which the appropriate winding is connected
   When entering transformer data, the rated voltage\textsuperscript{16} for all applicable windings should be specified. For non-LTC transformers, the winding voltage should be set to the tap voltage.

   A recommended approach is to model three-winding transformers such that the winding buses map to the transformer windings as follows:
   - H, or High-Voltage, Winding = Winding 1
   - X, or Low-Voltage, Winding = Winding 2
   - Y, or Tertiary-Voltage, Winding = Winding 3

   A recommended approach is to model two-winding transformers such that the winding buses map to the transformer windings as follows:
   - H, or High-Voltage, Winding = Winding 2
   - X, or Low-Voltage, Winding = Winding 1

   The two-winding\textsuperscript{17} transformer winding map is in this order by default since PSS®E requires all two-winding transformers with Load Tap Changers (LTCs) to specify the tap bus as Winding 1. While not all LTC transformers have the tap on the X winding, this is common with most transformers.

   b. Impedance(s)

   A recommended approach to modeling transformer impedance is to set the winding MVA base to the system MVA base which is 100 MVA, entered as positive sequence data in pairwise (delta) format. Care should be taken to when entering transformer impedance data to ensure that the data entered corresponds to the appropriate base (system or winding).

\textsuperscript{16} Care should be taken to enter the rated voltage, which may be different than the nominal voltage of the system for all transformer windings. There can be a difference between the rated voltage of the system and the transformer (nominal).

\textsuperscript{17} Two winding representation in PSS®E allows the user to select which bus number (from or to) the winding 1 resides.
Enter zero sequence data in the format appropriate to the connection code.

Connection codes <10:
- The zero sequence data must be entered as T-model format

Connection codes >10:
- The zero sequence data must be entered in pairwise (delta) format

c. Tap ratios
Depending on the PSS®E winding code used for the transformer, the setting should be either p.u. or kV. It should be noted, “tap ratio”, “winding ratio”, and “turns ratio” are synonymous.

- For transformers with no taps, use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
- For transformers with automatically adjusting, under-load tap changers (ULTC), it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
  - For parallel transformers, it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio for both transformers in order to prevent circulating VARs.
- For transformers with non-automatically adjusting, under-load tap changers (ULTC), it is recommended to use the tap ratio as set in the field.
- For transformers with no-load tap changers (NLTC), it is recommended to use the tap ratio as set in the field.
- It is recommended that Delta-Wye phase angle differences are incorporated appropriately in the models.

d. Minimum and maximum tap position limits
- Minimum and maximum tap position limits (RMIN and RMAX) shall be modeled based on transformer test report or manufacturer nameplate data.

e. Number of tap positions (for both the ULTC and NLTC)
- Under-load tap changers (ULTC) control bus, total number of tap positions, and tap setting shall be specified.
- No-load tap changers (NLTC) total number of tap positions and the tap setting shall be specified.
- Transformer tap positions are discrete. The total number of transformer tap positions is a fixed quantity and shall be entered. The maximum and minimum transformer tap positions represent the physical boundaries of the transformer’s capability to modify its winding impedance to achieve a control objective. Transformer tap changing control modes may include voltage regulation, as well as real and reactive power control. Automatically-adjusting under-load tap changing transformers (ULTC) shall specify a control mode, the bus that is being controlled, and the control limits defined by the maximum and minimum transformer tap positions.

18 It is noted that PSS®E provides transformer tap changer limit fields called VMAX and VMIN, regardless of control mode. For example, if a real power control mode is selected, the user must enter MW quantities in the VMAX and VMIN fields.
For transformers with untapped windings, the number of tap positions shall be "99" to indicate that there are no taps. PSS®E does not allow a value of "1" to be used as a tap position.

f. Regulated bus (for voltage regulating transformers)
   - The regulated bus is the location where the transformer is regulating voltage. Typically this regulated bus is connected to a transformer winding bus.
   - A limit difference of less than 0.0125 p.u. shall not be used when entering the regulated voltage band limits (VMAX, VMIN) for an automatically adjusting, under-load tap changers (ULTC) transformer.
   - It is recommended that the voltage band limits VMAX and VMIN be no less than 0.025 p.u., to prevent toggling of the ULTC during simulation iterations.

g. In-service status
   - In-service status, set to zero (0) if the device is not in-service.

h. Vector group and Connection code
   - The vector group shall match the topological configuration of the buses representing where the windings are connected (e.g., A 115/69 kV load serving transformer with a vector group of Dyn11 must show the winding 1 bus [Delta winding] as the 115 kV bus).
   - Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.
   - The transformer core construction should be considered (shell type or core type)

i. Transformers Controlling Reactive Power Flow
   - The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10

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20 Reference the TPL-007-1 Data Collection Template User Guide document under the Transformers section/Core Type. https://www.spp.org/spp-documents-filings/?id=197519
MVAR. Limits should accurately represent the actual operation of automatic control devices.

9. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes. PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:
   a. Real-time operational auto or manual adjustment operation of the PST.
   b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.
   c. Real-time operational MW flow limits (e.g. ±20 MW).
   d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).
   e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.
   f. Applicable long-term firm transmission service levels for the PST.

11. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

12. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

13. Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

14. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.
15. **Generator MVAR Limits** – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. **Small Generators, Capacitors, and Static VAR Devices** – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

17. **Coordination of Regulating Devices** – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

18. **Over and Under Voltage Regulation** – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

19. **Flowgates** – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

20. **Fixed Shunts** – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

21. **Switched Shunts** – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

22. **Static Var Systems** – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service status equal to zero. In-service Static Var Systems should be modeled with an in-service status equal to one.
23. DC Transmission systems – DC transmission systems must be represented with a sufficiently detailed model to simulate its expected behavior.

24. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

25. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence

1. A line whose impedance is very small as compared to that of a line connected in series with it. (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during Equivalencing.

4. A system's regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. Fictitious regulation of buses.

12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the “From” bus and the second-named bus is taken as the “To” bus. The “From” bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the “From” bus or tapped bus is specified with positive real power limits.
   e. The “Controlled Bus” specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of buses representing a model area. While typically analogous to a

21 The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

22 Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP23 loads and induction machine loads to be assigned to model areas that may be different than the buses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

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23 ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch \( P_{\text{gen}} \) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
**Transactions Data Requirements**

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

**Data Owner A**

![Physical circuitry tie is irrelevant.](image)

**Data Owner B**

**Source**

**Sink**

Inter-area Bilateral transaction description

Data Owner A exports MW to Data Owner B

Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>Data Series MDWG Model 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2015</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>Non SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2015</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

Figure 3. Example of Inter-area transfer (transaction).
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.

Figure 4. Example of Intra-area transfer (transaction).
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

**Transaction Update**
The transaction workbook should be updated to show a transaction from the control area where external resource is located to the generation owner control area. If the external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area’s number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

<table>
<thead>
<tr>
<th>No Transaction Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Area: XXX</td>
</tr>
<tr>
<td>Sink Area: YYY</td>
</tr>
<tr>
<td>Sink Load: XXX</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Transaction Needed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source Area: XXX</td>
</tr>
<tr>
<td>Sink Area: YYY</td>
</tr>
<tr>
<td>Sink Load: YYY</td>
</tr>
</tbody>
</table>

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPP reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the SPP RTO with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:
1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamic model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code

The schedule for submission of Dynamic data and list of MDWG Dynamic models [case types] can be found on the SPP corporate website, www.spp.org.

Dynamics Data Submittal Requirements and Guidelines
1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.
   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.
   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.
2. All synchronous generators and condensers shall also include representations of the generator, excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), Flexible AC Transmission System (FACTS), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

6. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

7. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

8. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

9. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

10. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

11. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.
Relay models

1. If a generator has in-service frequency and voltage protective relays that operate in 10 seconds or less, then the relay models shall be submitted when available. Inverter-based generator resources shall have frequency and voltage protective relay models. The generator frequency and voltage protective relay models in PSS®E are in the category of “Miscellaneous Other” models. See the following item regarding “Miscellaneous Other” models.

2. PSS®E Model Instance (MINS) values for “Miscellaneous Other” models should be a unique eight digit number. The first six digits should be the bus number at which the model is being applied. The last two digits should be a unique number designating a particular application of a “Miscellaneous Other” model at the bus. Under no circumstance shall a unique eight digit MINS number be repeated.

PSS®E Relay Model Types:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTGDCAT/VTGTPAT</td>
<td>Under/over voltage generator bus disconnection relay.</td>
</tr>
<tr>
<td></td>
<td>Under/over voltage generator trip relay.</td>
</tr>
<tr>
<td>FRQDCAT/FRQTPAT</td>
<td>Under/over frequency generator bus disconnection relay.</td>
</tr>
<tr>
<td></td>
<td>Under/over frequency generator trip relay.</td>
</tr>
</tbody>
</table>

MINS example: 59999900 VTGDCAT
Bus number = 599999
Unique identifier = 00
Relay model = VTGDCAT

PROCEDURE FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.

Commented (MO2): Provide language updates for SAT2T and SWCAPT models. When are these models needed? Explain why / when they are needed.
iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.

iv. Real and/or reactive power limits of +9999 or -9999.

c.

Checks which report abnormal values

v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]

vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]

vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.

viii. Branches with extreme impedances or tap ratios [BRCH].

Suggested options are:

a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.

b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.

c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.

d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [GNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]
c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]
d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].
e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory)
a. Specify CONEC, CONET, and COMPILE files.
b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using "user dynamics".
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE]
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.
      ii. A tabulation of conditions at each online machine
          a) Terminal voltage
          b) Exciter output voltage
          c) Real and reactive power output
          d) Power factor
          e) Machine angle in degrees
          f) Direct and quadrature axis currents on machine base.
      iii. A diagnosis of initial conditions, either
          a) "Initial conditions check OK", or
          b) A listing of suspect initial conditions generally states whose time derivative is not "small" (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.
          iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems.
This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of:
   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 "non-continuous" regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((- K) \approx (-1 / R)\), mechanical power to \((1 - 1/K)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Dynamic Data Format

**PSS®E Users**

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyr file software. Dyre file submittals can be changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

**Non-PSS®E Users**

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

Acceptable Dynamic Model Information
The PSS®E simulation software dynamic machine models may be used as long as they are included on the NERC List of Acceptable Models for Interconnection-Wide Modeling and not identified as unacceptable models on that list. The NERC acceptable dynamic model list can be found on the NERC SAMS website ➔ SAMS Reference Materials ➔ NERC Acceptable Model List.

Significant improvements to models may occur over time and models may become obsolete, not recommended, or unacceptable models. Unacceptable models might still be available in the PSS®E software; however, those models must be replaced with more suitable current acceptable models.

User-written dynamic models will only be allowed under the following conditions:

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis.
2. Dynamic model data is submitted in .dyr format.
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes.
4. Documentation, including Block Diagram, in .pdf or .docx format.
5. A written commitment from the Data Owner to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified of request for conversion to an acceptable model by SPP or Transmission Planner.

MDWG developed a subset list of acceptable dynamic models based on the NERC acceptable dynamic model list and adheres to the guidance outlined in the MDWG Dynamic Models Guidelines document.

Dynamics Data Validation Requirements

1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CDN conservation models, such as GENROA and GENSA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).
2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be
provided to MMWG when it becomes evident that accurate representation of interregional
dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator
Regional Coordinators have two options, described below, for submitting dynamics data to the
MMWG Coordinator.

Dynamics Data Updates Using Excel Template
Regional dynamics data updates are incremental to the dynamics data in the previous year
release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in
SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.
The table below describes the various types of updates and the required data and information
that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
<tr>
<td>Replace a model with another model of the same equipment group</td>
<td>Bus name, unit ID, model name for deleted model.</td>
<td>Yes for new model.</td>
<td>1. A DC exciter is replaced by a static exciter.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. A classical machine model is replaced by a detailed model.</td>
</tr>
<tr>
<td>Change bus name and/or unit ID for all models of an existing unit</td>
<td>Old and new names; old and new unit IDs</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Change bus number</td>
<td>No</td>
<td>No</td>
<td>Maintain the same name and unit ID and the model data will follow automatically.</td>
</tr>
<tr>
<td>Add dynamic models for a new generating unit</td>
<td>Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type</td>
<td>Yes</td>
<td>Same requirements whether unit is at new or existing bus.</td>
</tr>
<tr>
<td>Remove a unit and all associated models</td>
<td>Bus name, unit ID</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

Complete Set of Dynamics Data
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be
compatible and consistent with the MMWG steady-state selected for the dynamics cases that are
being developed. One file for all cases is preferable.
System Dynamic Data Base and Dynamic Simulation Cases
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators, the positive and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Mutual Impedance

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line. Zero-sequence current is only present during ground faults, so the consideration of mutual coupling effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence
fault current. It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSS®E, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSS®E models can be identified by checking when mutual impedance data is modeled and updated in a company's primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

**Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).** The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the MDWG Powerflow models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

All transformers shall have a Vector Group and corresponding Connection Code in PSS®E 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary

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analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of
the modeled sequence information prior to finalization.

Other information requested by the PC or TP - Information which the PC or TP deems necessary for
modeling purposes can be requested from Data Owners/Data Submitters.
SECTION 6: DEFINITIONS

These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner**

The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Data Submitter**

The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered a power export and a negative value is considered a power import.

---

25 Not a NERC functional entity
**Model Area** – The collection of model objects comprising an entity’s network and uniquely numbered in PSS®E.

**Peak Demand** – The highest demand including transmission losses for energy measured over a one clock hour period.26

**PSS®E** – Siemens PTI’s Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

**PSS®E MOD** – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

**PSS®MOD File Builder** – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS®MOD Modeling projects by comparing PSS®E models.

**Transaction (Model)** – A modeled purchase and/or sale of power.

**Non-scalable load** – Load that does not conform to the daily load duration curve.

**On-Peak (Model)** – Those hours or other periods typically considered periods of higher electrical demand.

**Off-Peak (Model)** – Those hours or other periods typically considered periods of lower electrical demand.

**Regulating device** – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

**Shortfall** – Occurs when an entity does not have enough dispatchable generation to serve the entity’s load.

**Tie Line (Model)** – A circuit connecting two Model Areas.

---

26 Attachment AA Resource Adequacy Section 2
SECTION 7: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,
From Area Name,
From Bus#,  
From Bus Name,
From Bus kV,
To Region Name,
To Area#,
To Area Name,
To Bus#,
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
G [pu],
B [pu],
Gj [pu],
Bj [pu],
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM11,
VMA1,
VM11,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#, 
Winding 1 Area Name,
Winding 1 Bus#, 
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#, 
Winding 2 Area Name,
Winding 2 Bus#, 
Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#, 
Winding 3 Area Name,
Winding 3 Bus#, 
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT, 
CW, 
CZ, 
CM, 
MAG1, 
MAG2, 
NMETR(1,2,3), 
NAME, 
STATUS(0,1), 
Owner 1, 
Fraction 1, 
Owner 2, 
Fraction 2, 
Owner 3, 
Fraction 3, 
Owner 4, 
Fraction 4, 
R1-2, 
X1-2, 
SBase1-2, 
R2-3, 
X2-3, 
SBASE2-3, 
R3-1,
Three Winding Transformer Data Fields - continued

X3-1, SBASE3-1, VMSTAR, ANSTAR, WindV1, NomV1, Ang1,
Summer Rating A1, Summer Rating B1, Summer Rating C1, Winter Rating A1, Winter Rating B1, Winter Rating C1, COD1,
Control Bus 1 Region, Control Bus 1 Area Number, Control Bus 1 Area Name, Control Bus #1 (CONT1),
Control Bus Name, Control Bus KV, RMA1, RM1, VMA1, VM1, NTP 1, TAB1, CR1, CX1, WindV2,
Control Bus 2 Region, Control Bus 2 Area Number, Control Bus 2 Area Name, CONT2, Control Bus 2 Name, Control Bus 2 KV, RMA2,
Three Winding Transformer Data Fields - continued

Two Terminal DC Tie Data Fields

In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (R,I),
DCVMIN,
CCCITMX,
CCCACC,
IP R REGION NAME,
IP R AREA#,
IP R AREA NAME,
IP R Bus#, 
IP R BUS NAME,
IP R BUS Kv,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#,
ICR AREA NAME,
ICR BUS#, 
ICR BUS NAME,
ICR BUS kv,
IFR REGION NAME,
IFR AREA#,
IFR AREA NAME,
IFR BUS#, 
IFR BUS NAME,
IFR BUS kv,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS #,
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAPR,
IP1 REGION NAME,
IP1 AREA #,
IP1 AREA NAME,
IP1 Bus #,
IP1 BUS NAME,
IP1 BUS KV,
NBI,
GAMMX,
GAMMN,
RCI,
XCI,
EBASI,
TRI,
TAPI,
TMXI,
TMNI,
STP I,
ICI REGION NAME,
ICI AREA #,
ICI AREA NAME,
ICI BUS #,
ICI BUS NAME,
ICI BUS KV,
IFI REGION NAME,
IFI AREA #,
IFI AREA NAME,
IFI BUS #,
IFI BUS NAME,
IFI BUS KV,
ITI REGION NAME,
ITI AREA #,
ITI AREA NAME,
ITI BUS #,
ITI BUS NAME,
ITI BUS KV,
IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
## SECTION 8: APPENDIX II
### UTILIZED IMPEDANCE CORRECTION TABLES

<table>
<thead>
<tr>
<th>Table Number</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
<th>Tap or Angle</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-60</td>
<td>0.36</td>
<td>-48.4</td>
<td>0.84</td>
<td>-36.1</td>
<td>0.84</td>
<td>-24.4</td>
<td>0.84</td>
<td>-12.4</td>
<td>0.84</td>
<td>0</td>
<td>0.84</td>
</tr>
<tr>
<td>2</td>
<td>-70</td>
<td>0.43</td>
<td>-59.3</td>
<td>1.21</td>
<td>-50.4</td>
<td>1.21</td>
<td>-41.6</td>
<td>1.21</td>
<td>-32.8</td>
<td>1.21</td>
<td>0</td>
<td>1.21</td>
</tr>
<tr>
<td>3</td>
<td>-80</td>
<td>0.55</td>
<td>-70.2</td>
<td>2.07</td>
<td>-61.3</td>
<td>2.07</td>
<td>-52.5</td>
<td>2.07</td>
<td>-43.1</td>
<td>2.07</td>
<td>0</td>
<td>2.07</td>
</tr>
<tr>
<td>4</td>
<td>-90</td>
<td>0.61</td>
<td>-80.2</td>
<td>3.01</td>
<td>-71.3</td>
<td>3.01</td>
<td>-62.5</td>
<td>3.01</td>
<td>-53.1</td>
<td>3.01</td>
<td>0</td>
<td>3.01</td>
</tr>
<tr>
<td>5</td>
<td>-100</td>
<td>0.75</td>
<td>-90.2</td>
<td>4.04</td>
<td>-81.3</td>
<td>4.04</td>
<td>-72.5</td>
<td>4.04</td>
<td>-63.1</td>
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<td>0</td>
<td>4.04</td>
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<td>-91.3</td>
<td>5.07</td>
<td>-82.5</td>
<td>5.07</td>
<td>-73.1</td>
<td>5.07</td>
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<td>5.07</td>
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<tr>
<td>7</td>
<td>-120</td>
<td>1.10</td>
<td>-110.2</td>
<td>6.11</td>
<td>-101.3</td>
<td>6.11</td>
<td>-92.5</td>
<td>6.11</td>
<td>-83.1</td>
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<td>6.11</td>
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<tr>
<td>8</td>
<td>-130</td>
<td>1.30</td>
<td>-120.2</td>
<td>7.14</td>
<td>-112.3</td>
<td>7.14</td>
<td>-103.5</td>
<td>7.14</td>
<td>-94.1</td>
<td>7.14</td>
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<td>7.14</td>
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<tr>
<td>9</td>
<td>-140</td>
<td>1.55</td>
<td>-130.2</td>
<td>8.19</td>
<td>-123.3</td>
<td>8.19</td>
<td>-114.5</td>
<td>8.19</td>
<td>-105.1</td>
<td>8.19</td>
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<td>-140.2</td>
<td>9.23</td>
<td>-134.3</td>
<td>9.23</td>
<td>-125.5</td>
<td>9.23</td>
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<td>9.23</td>
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<td>-150.2</td>
<td>10.29</td>
<td>-146.3</td>
<td>10.29</td>
<td>-136.5</td>
<td>10.29</td>
<td>-126.1</td>
<td>10.29</td>
<td>0</td>
<td>10.29</td>
</tr>
<tr>
<td>12</td>
<td>-170</td>
<td>3.30</td>
<td>-160.2</td>
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<td>11.34</td>
<td>-146.5</td>
<td>11.34</td>
<td>-136.1</td>
<td>11.34</td>
<td>0</td>
<td>11.34</td>
</tr>
</tbody>
</table>

**Notes:**
- The table entries represent the utilization of impedance correction factors for various taps and angles.
- The factors are applied sequentially for each tap and angle combination.
- The table is designed to facilitate the calculation of impedance corrections in electrical systems.

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**SPP Model Development Procedure Manual**

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SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice
Designating MOD-032-1 Data Submittal Assignment

On this _____ day of __________, 20____, _______________ and __________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following:

On __________, 20____, _______________ Data Owner, and _______________ Data Submitter, entered into an agreement through which _______________ has agreed to submit on behalf of _______________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

__________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________
__________________________________________________________________________________________________________________

The accuracy of the data is the responsibility of the Data Owner. This notice does not shift the compliance obligation from the Data Owner to the Data Submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER:
By: ______________________
Printed Name: ______________
Title: ______________________
Date: _______________

SPP hereby acknowledges receipt of this notice.
By: ______________________
Printed Name: ______________
Title: ______________________
Date: _______________

On behalf of DATA SUBMITTER:
By: ______________________
Printed Name: ______________
Title: ______________________
Date: _______________
### SPP MOD Project Type/Status Matrix

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Description</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP-approved Transmission System Upgrade</td>
<td>Most have an NTC for:</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Material transmission changes identified by SPP and may be included in model sets. For material changes, Data Submitters shall submit an RMS ticket as a way of notifying SPP. The status for this MOD type will only be changed to &quot;Acknowledged&quot; by Data Submitters after receiving a notification from SPP for inclusion in the model sets.</td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
<td>Up-rated change to the Transmission System that does not yet have or does not require an NTC, including:</td>
<td>Acknowledged</td>
<td>X X X X X</td>
<td>Material transmission changes that have been acknowledged by SPP and may be included in model sets. For material changes, Data Submitters shall submit an RMS ticket as a way of notifying SPP. The status for this MOD type will only be changed to &quot;Acknowledged&quot; by Data Submitters after receiving a notification from SPP for inclusion in the model sets.</td>
</tr>
<tr>
<td></td>
<td>1) Transmission changes budgeted for or planned for the TO;</td>
<td>Requested</td>
<td>X X X X X</td>
<td>Material transmission changes that have not yet been submitted to or have not yet been included in model sets.</td>
</tr>
<tr>
<td></td>
<td>2) Transmission changes budgeted for by a Transmission Customer or other entity;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) Transmission changes resulting from an emergency (e.g., unplanned equipment failure);</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4) Transmission, lead, or generation changes that otherwise have a strong likelihood or need for scheduling (e.g., software changes, hardware-related changes);</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>5) Transmission service request(s);</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>System Intact Alteration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Changes in load and/or delivery points approved in accordance with Attachment AQ, including any transmission changes associated with the Attachment AQ project (e.g., equipment upgrades, changes to normally-opened/closed topology);</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Material transmission changes identified by SPP and may be included in model sets.</td>
</tr>
<tr>
<td></td>
<td>Additions or changes to generating units, including any transmission changes associated with the Generation Interconnection Service project, approved in accordance with the Generator Interconnection Procedures (GIP) that:</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Generator changes and transmission changes, including upgrades that may have been included in the executed IA, associated with the approved Attachment AQ load modifications.</td>
</tr>
<tr>
<td></td>
<td>1) have an executed Interconnection Agreement (IA) or executed interim Generator Interconnection Agreement (GIA), and</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2) are not suspended.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Network Status</td>
<td>Update</td>
<td>X X X X X</td>
<td>Changes to the existing SPP Transmission System network topological status only (both placed out-of-service or returned to service).</td>
</tr>
<tr>
<td></td>
<td>Modeling Correlation</td>
<td>Update</td>
<td>X X X X X</td>
<td>Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD network data.</td>
</tr>
<tr>
<td></td>
<td>System Intact Alteration</td>
<td>Update</td>
<td>X X X X X</td>
<td>Changes to the transmission model necessary to correct baseline system load voltage (e.g., to conform to MMWG voltage criteria), thermal criteria violations, or other baseline condition modifications (e.g., addition of an exploratory generating unit which provided resource for NTC).</td>
</tr>
</tbody>
</table>

**Notes:**
- MDWG ITP TS GI: Projects with this status will be immediately committed to the MDG base case upon review.
- Special Study: Projects with this status will not be applied to any models except to those models submitted to MDWG.
SECTION 11: APPENDIX VII GMD/GIC DATA COLLECTION TEMPLATE USER’S GUIDE

GEOMAGNETIC DISTURBANCE MODELING DATA

Additional modeling data is necessary to supplement the MDWG steady-state models to support geomagnetic disturbance (GMD) analysis. The SPP GMD Model Set combines GMD-related system information (described below) with the MDWG AC-equivalent representation of the SPP transmission system. This composite of modeling data yields a DC-equivalent representation used to calculate geomagnetically-induced current (GIC) flows. These GIC magnitudes can then be applied to the MDWG AC-equivalent model to yield steady-state effects to System voltages and transformer MVAR losses. Appropriate simulations of GMD effects to the BES cannot be achieved without the incorporation of the following modeling information:

Substation Data
Substation modeling data encompasses geographical information related to power system topological information, as represented by the bus-branch model.

Bus Number (Planning Model): This is the actual bus from the Planning Model. This bus will be associated with a substation on the Substations sheet.

Substation Bus Number (Planning Model): Choose one bus to serve as the substation reference. In other words, the bus number annotated in this field will serve as the geographic reference for the entire substation. The recommendation is for the model Data Submitter to pick the highest voltage bus in a station to serve as this reference.

Substation DC Grounding Resistance (Ohms): This can be a measured, calculated, or assumed value for the grounding resistance in Ohms. Caution: do not convert this grounding resistance to per unit Ohms; retain the actual Ohmic quantity. In the unlikely event that a substation/switchyard is ungrounded, the model Data Submitter may enter “-1” here, not zero. Measured values come from ground grid testing, while calculated values are derived from detailed design modeling. When a substation is commissioned or periodic maintenance is performed, grounding integrity or ground grid data is typically collected.

Grounding Resistance (Method): This field indicates how the grounding resistance information was obtained.

Geographic Latitude (decimal degrees): This latitude will be used for all busses assigned to this station on the “Buses” sheet. Given that the entire SPP footprint is in the Northern Hemisphere, only positive decimal degree values are acceptable for latitude.
Geographic Longitude (decimal degrees): This longitude will be used for all busses assigned to this station on the "Busses" sheet. Caution: longitudes to the west of the Prime Meridian are between 0 and -180°. Given that the entire SPP footprint falls between the 85th west meridian and the 115th west meridian, only negative decimal degree values are acceptable for longitude.

Earth Model (Name): This field assigns the one-dimension earth conductivity model to the geographical location of the substation reference bus. The earth model is based upon the standard earth conductivity models developed by the United States Geological Survey (USGS). The following table shows the cross-reference between the USGS reference and the software code that should be placed in the "Earth Model (Name)" field. On the "1D Earth Model Reference" sheet, a tool is provided to assist in determining the proper earth model by latitude and longitude.

<table>
<thead>
<tr>
<th>USGS Earth Conductivity Model</th>
<th>Equivalent to:</th>
<th>Siemens/PTI software code (enter into the &quot;Earth Model Name&quot; field)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK-1A</td>
<td>AK1A</td>
<td>Adirondack Mountains-1A</td>
<td></td>
</tr>
<tr>
<td>AK-1B</td>
<td>AK1B</td>
<td>Adirondack Mountains-1B</td>
<td></td>
</tr>
<tr>
<td>AP-1</td>
<td>AP1</td>
<td>Appalachian Plateaus</td>
<td></td>
</tr>
<tr>
<td>AP-2</td>
<td>AP2</td>
<td>Northern Appalachian Plateaus</td>
<td></td>
</tr>
<tr>
<td>ATLANTIC</td>
<td>ATLANTIC</td>
<td>Northeastern Atlantic Coast, Nova Scotia</td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>BC</td>
<td>British Columbia</td>
<td></td>
</tr>
<tr>
<td>BR-1</td>
<td>BR1</td>
<td>Northwest Basin and Range</td>
<td></td>
</tr>
<tr>
<td>CI-1</td>
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<td></td>
</tr>
<tr>
<td>CP-1</td>
<td>CP1</td>
<td>Coastal Plain [South Carolina]</td>
<td></td>
</tr>
<tr>
<td>CP-2</td>
<td>CP2</td>
<td>Coastal Plain [Georgia]</td>
<td></td>
</tr>
<tr>
<td>CS-1</td>
<td>CS1</td>
<td>Cascade-Sierra Mountains</td>
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<td>Florida</td>
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<tr>
<td>IP-1</td>
<td>IP1</td>
<td>Interior Plains [North Dakota]</td>
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</tr>
<tr>
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<td>IP2</td>
<td>Interior Plains</td>
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<td>IP3</td>
<td>Interior Plains [Michigan]</td>
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<tr>
<td>IP-4</td>
<td>IP4</td>
<td>Interior Plains [Great Plains]</td>
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</tr>
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<td>PT-1</td>
<td>FE1</td>
<td>Mid-Atlantic</td>
</tr>
<tr>
<td>NE-1</td>
<td>NE1</td>
<td>New England</td>
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</table>
Transformers

The Transformers sheet is intended to collect all of the information necessary to properly determine the magnitude of GIC that will arise within a given transformer. It is important to note that transformer winding resistance data collected from transformer specification sheets or test reports may represent the total resistance of the three phases combined.

While well known to model Data Submitters, the convention for MDWG model data is consistent with most load flow software that requires data to be submitted per phase. Therefore, any combined three-phase transformer winding resistance data must be divided by three prior to submitting quantities. Similarly, when DC resistances of transformer windings are unknown (estimated values should only be used when data are unavailable), a reasonable assumption is to substitute actual data with 50% of the per phase copper loss resistance. It is noted that total copper loss resistance may be converted to per phase by dividing by three, and all values should be entered as Ohms, not in per unit base. For example, transformer test reports typically report the total copper loss of a transformer, derived from a short-circuit test, either as a total copper loss power [W] or as the total winding resistance [ohms] calculated from the total copper loss power. In either case, these quantities represent the total copper loss effects of three windings combined and must be divided by three to properly reflect the per phase resistance. The model Data Submitter is expected to provide the following data:

Core Type: This indicates the number of cores in transformer core design and is used to calculate transformer reactive power loss from GIC flowing in its winding. This field is only used by the software when a K-factor quantity is not specified by the model Data Submitter for the transformer.

---

27 Also known as a transformer impedance test, a typical transformer short-circuit test is performed by shorting the low-voltage winding and increasing the high-voltage winding voltage until transformer rated current is observed in the high-voltage winding. This test recognizes that core loss is negligible, yielding the resistive losses in the primary winding circuit.
In other words, if you know the K-factor for the transformer (or have a better assumption), enter the quantity in the "GIC Reactive Loss Factor (K-factor)" field and it diminishes the importance of the "Core Type" field. Otherwise, the values for this field are limited to:

<table>
<thead>
<tr>
<th>Code</th>
<th>Core Design Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Three-phase shell configuration</td>
</tr>
<tr>
<td>0</td>
<td>Unknown core design</td>
</tr>
<tr>
<td>1</td>
<td>Three separate single phase cores design</td>
</tr>
<tr>
<td>3</td>
<td>Three phase, 3-legged core configuration</td>
</tr>
<tr>
<td>5</td>
<td>Three phase, 5-legged core configuration</td>
</tr>
<tr>
<td>7</td>
<td>Three phase, 7-legged core configuration</td>
</tr>
</tbody>
</table>

If the core configuration is unknown, stating as such in the Core Type field is acceptable. When this is done, the software will make an assumption for K-factor based upon the voltage level of the highest winding voltage of that transformer. All transformers in the SPP MDWG model series are expected to have vector groups defined, so that T-modeling of transformers in the DC network is permitted.

Connection Code (CC): This is the field for the Data Submitter to update the Connection Code shown in the Existing Connection Code (CC) field, if warranted. This field is included because experience has shown that prior model-building efforts may not have focused on this data, but it is critical to GIC modeling. It is suggested that the model Data Submitter review vector group and winding order to ensure proper CC submittal.

Vector Group: This is key data required to properly model the grounding characteristics of a transformer. While potentially misleading, most load flow software packages embed the transformer per phase winding configuration information under short-circuit data category. The confusing aspect is that winding configuration is meaningful in situations other than under short-circuit conditions; for example, with GIC that arise from GMD. As a reminder, the Connection Code data contained within the load flow model representation embodies concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation.

GIC Reactive Loss Factor (K-factor): The K-factor is an important aggregated assumption that helps formulate the transformer sensitivity to half-cycle saturation that arises from the contribution of GIC. In other words, the K-factor indicates a measure of increased reactive power losses in the transformer when subjected to GICs. The units of K-factor are MVAR per Ampere; the larger the K-factor the larger expected reactive power losses in the transformer. K-factor is used to calculate additional transformer reactive power losses according to:

\[ Q_{loss} = \text{Effective GIC Winding Current} \times \text{K-Factor} \]
There is much debate in industry about how to measure, calculate, and assume values for K-factor. In general, if a K-factor is not specified on a transformer data sheet or in test reports, the following table annotates appropriate assumed values. It is noted that the following assumptions for K-factor are consistent with those integrated into the Siemens/PTI software:

<table>
<thead>
<tr>
<th>Core Type Code</th>
<th>Highest Winding kV</th>
<th>K-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Any</td>
<td>0.33</td>
</tr>
<tr>
<td>0</td>
<td>&lt;=200 kV</td>
<td>0.6</td>
</tr>
<tr>
<td>3</td>
<td>&gt; 200kV, &lt;= 400kV</td>
<td>0.6</td>
</tr>
<tr>
<td>4</td>
<td>&gt; 400kV</td>
<td>1.1</td>
</tr>
<tr>
<td>1</td>
<td>Any</td>
<td>1.18</td>
</tr>
<tr>
<td>3</td>
<td>Any</td>
<td>0.29</td>
</tr>
<tr>
<td>5</td>
<td>Any</td>
<td>0.66</td>
</tr>
<tr>
<td>7</td>
<td>Any</td>
<td>0.66</td>
</tr>
</tbody>
</table>

DC Resistance of From, To, and Tertiary Windings (Ohms/Phase): The preferred value is measured, typically derived from a transformer specification sheet or test report. This data should be the measured DC resistance of single winding at nominal tap and adjusted to 75 °C. Caution: do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

From, To, and Tertiary Windings Grounding Resistance (Ohms): The preferred value is measured or calculated, typically derived from a ground grid design, transformer test report, or other test report. This data should be the measured DC resistance of single winding at nominal tap and adjusted to 75 °C. Caution: do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

Blocking Device Status (From, To, and Tertiary Windings): Indicate whether a GIC blocking device is installed and is operational on the From winding in this field. GIC blocking devices on transformer windings are rare.

DC Resistance of From, To, and Tertiary Windings Blocking Device (Ohms): Currently, most load flow software tools that support a GIC analysis module assume that if a blocking device is installed and active, the DC resistance of that block is infinite. In other words, the winding is either blocked from participating in GIC flow or not. It is expected that in future versions GIC analysis modules that software will support an actual DC resistance for the blocking device to more precisely model GIC flow through the transformer winding. Input the known DC resistance of the blocking device in Ohms, if known.
Transformer Model in DC Network: Entered as 0 to represent the transformer according to its vector
group, or entered as 1 to represent the transformer as a T-model. **Important note:** given that all
transformers in the SPP MDWG model series are expected to have vector groups defined, the **model
Data** Submitter should avoid entering 1 in this field. In future revisions of the MDWG model data
collection, this field may be eliminated. However, due to an outstanding PSS®E software ambiguity
for symmetric phase shifting transformers, this field is retained.

**Symmetric phase shifting transformers modulate real power flow, typically to a narrow specified
range. These are represented in the load flow model by two-winding transformer representations
that utilize the "MW symmetrical PAR" or "MW asymmetrical PAR" control mode. These
transformers should be modeled as the YNq vector group with Connection Codes (CC) 9 or 19,
reflecting that the winding 1 impedance represents the zero sequence impedance of the regulating
transformer; the winding 2 impedance represents the zero sequence impedance of the series
transformer, and the shunt branch represents the tertiary winding impedance. If the symmetric
phase shifting transformer is entered this way, the "Transformer Model in DC Network" (TMODEL)
should be entered as 0. However, in those rare cases when a vector group is not specified for the
symmetric phase shifting transformer, the PSS®E software needs to establish a default for the
transformer T-model representation in DC analysis. This is accomplished by entering the
"Transformer Model in DC Network" (TMODEL) as 1.

**Shunts**
The Shunts sheet is intended to collect information necessary for modeling direct paths to ground
that contribute to the magnitude of GIC flow on the power system. There are two key observations
that need to be considered when submitting shunts data for MDWG model data collection. First,
Switch Shunt capacitor devices are not considered by GIC analysis software. This is due to the
expectation that capacitive shunts are GIC blocks and inductive devices would be intentionally placed
out-of-service so as to not exacerbate GIC during GMD events. Second, line reactor devices are very
important for modeling GIC. However, the practice of representing line reactors is inconsistent
amongst model builders, where some explicitly model line reactor shunts at buses in the
transmission line path, while others incorporate the impedance of the line shunt into the [data record]
of the transmission line branch itself. It is important to confirm how line shunts are being modeled.
The **model Data** Submitter is expected to provide the following data:

From, To Bus Number (Planning Model): Self-explanatory; where the fixed shunt is located. In the
case where the line shunt is modeled as part of the transmission line branch, enter the bus number
of the branch terminal end that is closest to the physical location of the line reactor. If line reactors
reside at both ends of the branch, make two separate line item entries (e.g., separate rows) to reflect
two separate line reactors.

Line or Bus (Planning Model): Enter the method of modeling the shunt device, as either explicitly at
a bus or as part of a line (branch).

Located at which end (From, To, or Both): For line shunts modeled as part of the transmission line
branch, enter at which terminal ends the line reactor is installed. Otherwise, leave this field blank.
Winding Connection Type: This information is not currently used as part of the analysis, but may be relevant in future assessments. Enter the winding configuration as Wye, Grounded-Wye, or Delta. This information should be annotated on the shunt specification sheet or as part of a test report.

Shunt DC Resistance (Ohms/Phase): The preferred value is measured, typically derived from the shunt specification sheet or test report. This data should be the measured DC resistance of single phase and adjusted to 75 °C. Caution: do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

Shunt Grounding Resistance (Ohms): The preferred value is measured or calculated, typically derived from a ground grid design, shunt test report, or other test report. This data should be the measured DC resistance of single phase and adjusted to 75 °C. Caution: do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

Branch

The Branch sheet is intended to reflect the characteristics of the transmission lines that serve as the current-carrying conductors participating in the varying magnetic field, giving rise to GIC. It is noted that most of the information for transmission lines is already part of load flow models. The model Data Submitter is expected to provide the following data:

Branch Resistance (pu): Most branch resistances are known in per unit, so an automatic conversion to ohms per phase is included here. The ohms per phase quantity can be entered explicitly in the DC Resistance cell or, if Branch Resistance (pu) is left as zero, the GIC module will use the AC branch resistance already in load flow model. It is important to note: this “Branch Resistance” field refers to the DC branch resistance that will characterize the transmission line in the DC model representation for GIC analysis. For the purpose of the MDWG model data collection, all transmission line conductor DC resistances shall be entered at 50 °C.

For an identical temperature, transmission line branch per phase resistances vary slightly between DC resistance and AC resistance. However, for large diameter transmission line conductors, the difference between AC and DC resistances may exceed 10%, at a common temperature. This is especially important when considering whether a transmission line employs bundled conductors. For the purpose of MDWG model data collection, it is acceptable to use the AC branch resistance already in the load flow model, if the AC resistance is based on 50 °C or less. However, care must be taken when using AC resistances as approximations of the DC resistance, especially when the AC resistance is based on temperatures greater than 50 °C. While conductor resistivity increases approximately linearly with temperature between 20 °C to 75 °C, the difference between DC and AC resistances may vary non-linearly with temperature given other transmission line characteristics, leading to significant differences in resistance. In other words, knowing that transmission line AC resistances are often entered into the load flow models at 25 °C, using this AC resistance as a conservative approximation for DC resistance is acceptable. However, any AC resistance entered into

---

28 The Transmission Line Characteristics (TMLC) software and Line Properties Calculator (LineProp) software are common tools used by model Data Submitters to calculate AC transmission line branch impedances. Both of these software packages do not allow any other conductor temperature assumption other than 25 °C, when calculating AC resistance calculation, unless default manufacturer data tables are overwritten. Typical transmission line conductor tables furnished by manufacturers provide AC resistances at 25 °C, 50 °C, and 75 °C.
the load flow model using temperatures greater than 50 °C must be corrected to 50 °C prior to using the quantity as the approximation for DC resistance.

Ultimately, to perform a conservative study of GMD effects, the smaller the transmission line DC resistance, the larger the GIC that will be developed. Therefore, DC resistances entered at 50 °C are preferred. AC resistances corrected to and entered at 50 °C or less are an acceptable alternative.

Real part of total branch GMD-induced electric field (volts): This field is intended to allow a particular branch to experience a higher or lower induced electric field than the uniform field applied to other branches. In other words, if there is a reason to expect a particular transmission line will experience more or less induced field during a benchmark GMD event (line length times the TPL-007-3 reference geoelectric field of 8V/km), enter the alternative real-part electric field in volts. Caution: do not enter zeros into this field unless the transmission line is not intended to participate in the development of an electric field due to GMD. Rare examples of when this may be the case include buried or undersea transmission cable. Leave this field blank to apply the uniform electric field automatically.

Imaginary part of total branch GMD-induced electric field (volts): This field is intended to allow a particular branch to experience a higher or lower induced electric field than the uniform field applied to other branches. In other words, if there is a reason to expect a particular transmission line will experience more or less induced field during a benchmark GMD event (line length times the TPL-007-3 reference geoelectric field of 8V/km), enter the alternative imaginary-part electric field in volts. Caution: do not enter zeros into this field unless the transmission line is not intended to participate in the development of an electric field due to GMD. Rare examples of when this may be the case include buried or undersea transmission cable. Leave this field blank to apply the uniform electric field automatically.

**Loads**

**Note: loads for GMD data submittal are expected to be exceptions and are uncommon!** Albeit rare, the possibility exists that a relevant load may be connected at EHV/HV levels that offers a ground path for GIC. Likewise, it may be desirable for a Data Submitter to include data for a solidly-grounded load direct-served through an EHV/HV autotransformer (uncommon), such as with a large industrial load. All loads do not need to be entered into the Loads sheet! The Loads sheet is intended to collect information necessary for modeling the rare direct paths to ground introduced due to load connections that contribute to the magnitude of GIC flow on the power system. The model Data Submitter is expected to provide the following data:

**Winding Connection Type:** This information is not currently used as part of the analysis, but may be relevant in future assessments. Enter the winding configuration as Wye, Grounded-Wye, or Delta. For loads with a dedicated step-down transformer, this information may be annotated on the step-down transformer specification sheet or as part of a test report for the primary winding (non-autotransformer) or the primary-secondary autotransformer winding configuration.

**Load DC Resistance (Ohms/Phase):** The Data Submitter should take care when entering this value. Remember, for autotransformers, the common winding (primary and secondary) is likely grounded. When determining the load DC resistance, consider that the actual impedance of the load to ground is connected to the secondary in parallel with the tapped common winding. The preferred value is
measured DC resistance of single phase and adjusted to 75 °C, but the common winding to ground resistance may be a suitable proxy for DC analysis. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Load Grounding Resistance (Ohms):** The preferred value is measured or calculated, typically derived from the step-down transformer test report indicating the transformer neutral grounding. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.
### SECTION 12: APPENDIX V MOD-032-1
#### ATTACHMENT 1

**MOD-032-1 – ATTACHMENT 1**

The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity\(^29\) responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)</td>
<td>(If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</td>
<td></td>
</tr>
<tr>
<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>a. Positive Sequence Data</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>b. Negative Sequence Data</td>
</tr>
<tr>
<td>2. Aggregate Demand(^29) [LSE]</td>
<td>4. Power System Stabilizer [GO, RP (for future planned resources only)]</td>
<td>c. Zero Sequence Data</td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td>5. Demand [LSE]</td>
<td>2. Mutual Line Impedance Data [TO]</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td>6. Wind Turbine Data [GO]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>3. Generating Units(^30) [GO, RP (for future planned resources only)]</td>
<td>7. Photovoltaic systems [GO]</td>
<td></td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
<td></td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td>9. DC system models [TO]</td>
<td></td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide</td>
<td>10. Other information requested by the Planning Coordinator</td>
<td></td>
</tr>
</tbody>
</table>

---

\(^29\)For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

\(^2\) For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

\(^3\) Including synchronous condensers and pumped storage.
<table>
<thead>
<tr>
<th>Data in the same manner as that required for aggregate Demand under item 2, above</th>
<th>Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
<td></td>
</tr>
<tr>
<td>e. machine MVA base</td>
<td></td>
</tr>
<tr>
<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
<td></td>
</tr>
<tr>
<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
<td></td>
</tr>
<tr>
<td>h. in-service status*</td>
<td></td>
</tr>
</tbody>
</table>

4. AC Transmission Line or Circuit [TO]
   a. impedance parameters (positive sequence) | |
   b. susceptance (line charging) | |
   c. ratings (normal and emergency)* | |
   d. in-service status* | |

5. DC Transmission systems [TO] | |

6. Transformer (voltage and phase-shifting) [TO]
   a. nominal voltages of windings | |
   b. impedance(s) | |
   c. tap ratios (voltage or phase angle)* | |
   d. minimum and maximum tap position limits | |
   e. number of tap positions for both the ULTC and NLTC | |
   f. regulated bus (for voltage regulating transformers)* | |
   g. ratings (normal and emergency)* | |
   h. in-service status* | |
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GD, LSE, TO, TSP]
## REVISION HISTORY

<table>
<thead>
<tr>
<th>DATE OR VERSION NUMBER</th>
<th>AUTHOR</th>
<th>CHANGE DESCRIPTION</th>
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<td>Updated Aux Load Shunt Data, ESR DER data updates</td>
<td>2021 Series MDWG Model Build</td>
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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, Data Owners, equipment, and Data Submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1),1 and the provisions of the

1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

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\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

Applicable Data Submitters

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

A completed Letter of Notice identifying responsibilities between a Data Owner and a Data Submitter is required to be submitted to SPP. This Letter of Notice is included in the appendix section.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Good modeling practice includes coordination of data submissions to the SPP PC that impact other systems with those Data Owners of impacted systems.
**Applicable Equipment**

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the Bulk Electric System (BES).
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.

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5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.

6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement

7 Sixth Revised Volume No.1, Attachment AI, Part II-1.
8 Sixth Revised Volume No.1, Attachment AI, Part II-2.
9 Sixth Revised Volume No.1, Part III-30.
10 Sixth Revised Volume No.1, Part III-31.
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes.** In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format

PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Spring Peak</td>
<td>Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>Annual Summer Shoulder</td>
<td>Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>Annual Summer Peak</td>
<td>Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>Annual Fall Peak</td>
<td>Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>Annual Winter Peak</td>
<td>Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 April Minimum</td>
<td>Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>Annual + 1 Spring Peak</td>
<td>Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 Summer Shoulder</td>
<td>Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models...
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

**Data Transmittal**
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic** --- GlobalScape
2. **E-MAIL** --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the "SPP MDWG File Sharing Site", GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP Model Release Guidelines**

**Steady-State and Short Circuit Models**
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.

**SPP Model Contact:**
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

**Request an SPP Map / Model**

You may request an SPP Transmission Map/Model through the [Request Management System](https://spp.org) by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult [SPP Maps & Models FAQ](https://spp.org).

_Last Updated July 26, 2018_

**MMWG Deliverables**

**Regional Coordinators**

The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. **Steady-State Cases**
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format.
   b. Tieline and interchange data in the specified format.
   c. IDEV files for any data changes.
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. **Dynamics Cases**
   a. Dynamics input data in DYRE format for new models.
   b. SDDB Excel worksheet for changes to the database.
   c. FLECS code and documentation for user defined models.
   d. Load conversion CONL file sorted by area.
   e. List of netted generation buses.
   f. Two contingency events per region in IDEV format.

**MMWG Coordinator(s)**

The MMWG Coordinator(s) will post the following to the [ERAG Web Site](http://spp.org).

1. **Steady-State Cases**
   a. Initialized steady state and regional contingency cases.
2. **Dynamics Cases**
   a. Dynamics input data in DYRE format.
   b. FLECS code for user defined models.
   c. Load conversion CONL file sorted by area.
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case.

4. Final reports.

**System Abbreviations & Area Number Assignments**

System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

**MDWG Contact List**
The MDWG Contact List can be found on SPP’s GlobalScape under Modeling (CEII, RSD) ➔ SPP Modeling Contacts ➔ 3. Final Modeling Contacts

**NOTE** – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

**Compliance**

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, long name, and associated Auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts that meet TPL-001 requirements shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be not Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such
location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have an updated service agreement, or are in the process of finalizing a service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS® E idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Not Coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

**On-Peak/Off-Peak Models**

Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority Coincident Peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1st through September 30th</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1st through November 30th</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1st through March 31st</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1st through May 31st</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1st through September 30th</td>
</tr>
</tbody>
</table>

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.
Load Data
Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID "R1"). These loads should be maintained in the Load Mapping worksheet of the EDST.

Area Summary Report
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**

Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**

Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The “from bus,” “to bus,” and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.
3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional.

6. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

7. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range. For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc.).
NOTE: When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

1. For generator regulated buses, a desired voltage set point will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the Station Service or Auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.
SHUNT DATA

Shunt reactive devices are key components used, in conjunction with generating unit excitation, to regulate transmission system voltage, as well as facilitate operating flexibility while assisting to maximize transmission capacity. Shunt reactive devices are typically characterized as either static or dynamic, based upon their responsiveness to system voltage variations.

Static reactive devices tend to respond more slowly, either through automatic or manual switching according to a broader voltage schedule or range of system voltage conditions. Dynamic reactive devices tend to respond very quickly, automatically adjusting their reactive contributions to the system so as to maintain a voltage set point (Regulating device). The four primary static and dynamic reactive device categories are:

- **Fixed shunt device (Locally-switchable static devices)** - Typically require a switchman to physically close a switch in the field under de-energized conditions. These devices require human interaction at the location of the device in order to change the status and are not self-switching. These devices should be represented as fixed shunt devices in software simulations.

- **Switched Shunt, Locked mode (Remotely-switchable static devices)** - Can be placed in, or taken out of, service by a System Operator remotely operating a switch from a Control Center. These devices require human interaction in order to change the status, are not self-switching, are not used for automatic system adjustments, but are used for manual system adjustments (regulating device). These devices should be represented as switched shunt devices in locked mode (0) in software simulations and set to their expected seasonal Mvar (Binit) values.

- **Switched Shunt, Discrete mode (Automatically-switchable static devices)** - Can be placed in, or taken out of, service by an automatic controller (e.g., the Protection System) that actuates powered switch closure. These devices are self-switching, are used for automatic system adjustments (regulating device), but not used for manual system adjustments. These devices should be represented as switched shunt devices in a discrete switching mode (1, 3, 4, 5, or 6) in software simulations.

- **Switched Shunt, Continuous mode (Automatically-switchable dynamic devices)** - Reactive contribution is adjusted by an automatic controller. These devices are used for automatic system adjustments (regulating device), but not used for manual system adjustments. Examples of dynamic reactive devices include: static VAR compensators (SVC), static compensators (STATCOM), and direct current voltage source converters (VSC). These devices should be represented as switched shunt devices in a continuous switching mode (2) in software simulations.

Load flow software offers multiple options for modeling shunt reactive devices and care must be used when selecting the appropriate representation. The primary modeling capability considerations for non-rotating mass reactive devices are:
Shunt implementation: fixed, or switched.
Simulated control mode: Locked, discrete, or continuous.
Regulated voltage band limits: high \( (V_{hi}) \) and low \( (V_{lo}) \).

Upon selecting the appropriate modeling representation for the non-rotating mass shunt reactive device, the Data Owners/Data Submitter shall ensure that the following is entered for:

**Non-regulating shunt capacitor or reactor device (static, locally-switchable device)**
- Fixed shunt (no control mode) with a unique shunt ID.
- Total reactive device admittance \(^{11}\) (MW and MVAR) that represents the aggregated contribution of the reactive banks or blocks installed as a fixed device.
- In-service status, set to zero (0) if the device is not in-service.

**Regulating shunt devices**
- Switched shunt with 'SW' shunt ID (forced by software).
- Total reactive device admittance \(^{12}\) (MVAR only), differentiated into quantities of admittance that represent the installed controllable device reactive banks or blocks, as appropriate.
- Regulated voltage band limits, either as a schedule \( (V_{hi} \neq V_{lo}) \) for static reactive devices or as a set point \( (V_{hi} = V_{lo}) \) for dynamic reactive devices, appropriate to the equipment.
- Reactive limits, for dynamic reactive devices only.
- Control mode-of-operation, as listed above:
  - Static, remotely-switchable device – locked, control mode (0).
  - Static, automatically-switchable device - unlocked, discrete control modes (1, 3, 4, 5, or 6).
  - Dynamic device – unlocked, continuous control mode (2).
- Assignment of the regulated bus, for switched shunt representations only.
- In-service status, set to zero (0) if the device is not in-service.

The Data Owners/Data Submitter should consider the load flow numerical solution stability implications of the regulated voltage band limits \( (V_{hi}, V_{lo}) \) when entering data for the shunt reactive devices. The ability of the load flow numerical solver to derive an acceptable voltage state may be impeded by a switched shunt with a discrete control mode whose reactive contribution, when switched, pushes the voltage of its connected bus outside of convergence tolerances. Therefore, a limit difference of less than 0.025 pu shall not be used when entering the regulated voltage band limits \( (V_{hi}, V_{lo}) \) for a switched shunt reactive device. Similarly, switched shunts shall not be connected to generator buses or to a generator bus through a zero-impedance branch.

All shunt reactive devices attached at transmission-level buses (i.e., 60 kV or greater) or attached to the tertiary of a transmission-level power transformer shall be modeled explicitly and not as loads or aggregated with loads. Further, static reactive devices connected to transmission lines are known as line shunts. The PSS®E load flow software allows line shunts to be modeled as part of the BRANCH

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11 Shunt conductance and susceptance quantities are entered in units of MW and MVAR representing the total per-unit admittance at rated voltage, on system base MVA.

12 Shunt susceptance quantities (conductance is assumed to be zero) are entered in units of MVAR representing the total per-unit admittance at rated voltage, on system base MVA.
An alternative approach is to model the line shunt explicitly by using an intermediate bus and zero-impedance branch (ZBR), as shown in Figure 1, even when the line shunt is locally-switchable only and expected to match the in-service status of the connected branch. In this scenario, losing the transmission line, but not the line shunt, can cause low voltage conditions that may not be realistic.

The Data Owner/Data Submitter must remember that the switched shunt reactive device control mode employed by the load flow software offers significantly more flexibility than shunt reactive devices implemented in the transmission system. Care should be taken to best represent the actual operation of installed shunt reactive devices and not allow unlocked control modes when inappropriate. During the model build process, similar to the process of case conditioning prior to analysis, remotely-switchable devices may be unlocked and automatically-switchable devices may be locked, expressly for the purpose of obtaining a converged load flow solution. However, care must be taken to ensure that the final state of the model contains the correct control mode, including locking appropriate to the shunt reactive devices represented. The Data Owners/Data Submitters should also consider individual device protection settings as they relate to voltage.
control mode and limits.

**Generator Data**

Generating unit MW and MVAR output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits with consideration of MOD-025-2 and SPP Planning Criteria 7.1.1., or company-specific procedure for testing the gross capability of the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with Auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities.

For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to XSOURCE Table.

For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour.

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance information is provided.

When modeling mothballed and future retired units, the unit will be modeled offline (in-service status = 0). The capability amounts for PMAX, PMIN, QMAX, and QMIN should not be changed until the unit is fully decommissioned) similar to units that are not dispatched in the particular seasonal model. Unit retirement information will be provided in a separate document and posted through a secure website. Decommissioned units should be removed from the models.

**Modeling Process for Generator Parameters**

1. The Generator parameter P_{MAX} shall be modeled as a gross seasonal maximum capability based on SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.
b. Generating plant Station Service load and Auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All Station Service load and Auxiliary load representations shall:
   i. Be modeled explicitly on the appropriate bus, corresponding to the voltage to which the Auxiliary load is served. Model representations of Auxiliary load connected to the generating unit bus (Figure VII-1), Auxiliary load modeled with separate transformation (Figure VII-2), and Auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   ii. Be annotated as non-scalable.

![Diagram of plant configuration with notes and figures](image)

Figure VII-1. Common bus representation
Figure VII-2. Separate transformation representation
Figure VII-3. Transformer high-side representation

![Diagram showing plant configuration with load representations](image)

Figure VII-4.

Experience has shown that generating plant Station Service load and Auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant Station Service load and Auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable Station Service load and Auxiliary load.

If generating plant Station Service load and Auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant Station Service load and Auxiliary load shall use “$S_n$” in the Load ID for one or more aggregated generating plant Station Service loads (Figure VII-4a).

If generating plant Station Service load and Auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant $P_{gen}$ may be less than $P_{max}$) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant Station Service load and Auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b).

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13 Station Service load and Auxiliary load shall not be netted against generating plant dispatch by reducing the $P_{gen}$ of a unit with an amount corresponding to the plant Auxiliary load.
VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “F₁₄” in the Load ID field to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “V₁₄” in the Load ID field to designate variable load quantities that do vary with plant dispatch.

Aggregated Auxiliary Load “Sn”

a. Combined Auxiliary Load (Fixed) “F₁₄”

b. Combined Auxiliary Load (Variable) “V₁₄”

c. Discrete Station Heater Auxiliary Load (Fixed) “F₂”

d. Discrete Fuel Auger Auxiliary Load (Variable) “V₂”

e. Discrete Station Lighting Auxiliary Load (Fixed) “F₂”

Discrete Effluent Pump Auxiliary Load (Variable) “V₂”

Figure VII-4. Examples of generating plant Auxiliary load representations (aggregated, combined, and discrete).

Only generating plant Station Service load or Auxiliary load IDs should be labeled with “Sn”, “Fn”, or “Vn”; all other load types should be labeled differently.

Station Service or Auxiliary load modeling should be done in accordance with the state of the generator as follows:

<table>
<thead>
<tr>
<th>Generator State</th>
<th>Aggregated “Sn” SS or Aux Load</th>
<th>Variable “Vn” SS or Aux Load</th>
<th>Fixed “Fn” SS or Aux Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>In-Service</td>
<td>In-Service</td>
<td>In-Service</td>
</tr>
<tr>
<td>Offline</td>
<td>In-Service</td>
<td>Offline</td>
<td>In-Service</td>
</tr>
<tr>
<td>Decommissioned</td>
<td>Removed from model</td>
<td>Removed from model</td>
<td>Removed from model</td>
</tr>
</tbody>
</table>

Aggregated Station Service or Auxiliary loads shall be updated to reflect the dispatch of the associated generator.

Modeling of Wind/Solar Renewable Resources P_GEN

- Spring Light Load Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP minimum load hour corresponding to the season of the Light Load case, not to exceed each facility’s firm service amount. The methodology used to calculate replacement data is described in the ITP Manual. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

14 “n” represents a unique numeric value. PSS®E requires each load placed at a bus to have a unique Load ID.
• On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility’s latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident\(^{15}\) peak, not to exceed each facility’s firm service amount.

• SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build. Any renewable resource modeling data submitted to the PC, after the initial dispatch list is provided, will be dispatched at the seasonal state dispatch percentage of the renewable resource’s nameplate amount.

• When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

• Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

• For resources that do not have firm service, \(P_{\text{GEN}}\) values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

Shortfall Guidance Process
Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements.
   a. The in-service date shall be based on the expected in-service date of the GI study.
   b. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS\(^{\text{\textregistered}}\)E).
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future Exploratory Generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future Exploratory Generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS\(^{\text{\textregistered}}\)E) shall be used.
   b. When available, Exploratory Generation should be based upon the host TO Resource Plan.

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\(^{15}\) SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
d. The addition of Exploratory Generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

**EXTERNAL RESOURCE MODELING**

**Purpose**
This procedure assures that members adhere to a uniform process when modeling external resources in SPP.

**Modeling Process**
If a member acquires external resources outside their Model Area, the following modeling process should be followed:
1. All buses should be assigned numbers that are in the host’s Model Area bus number range.
2. Area Number/Name should be the host’s Model Area number.
3. Zone Number/Name should be in the host’s Model Area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

**Owner Data and Line Mileage Data (SSAE Control)**
To meet the Statement on Standards for Attestation Engagement (SSAE) requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:
1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

**Initial Run Review**
After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. **Area Interchange**
The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions
between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
   The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
   The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
   Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
   The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**
   Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWH and VSWL) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are
used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.

The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. $Q_T \text{ --- MAX} = \text{one-half of MW rating}$

ii. $Q_B \text{ --- MIN} = \text{negative one-third of MW rating}$

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The
desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)
SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates
At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc…) There are several ways of submitting changes to the steady-state models.

Two of these methods are:
1. Using the steady-state update procedure to update MOD.
2. Submitting a PTI IDEV format file to perform the RDCH operation. This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.

It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format
Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a comma (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is added to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The modification of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data
for that bus will be removed (e.g., branches, transformers, generators, and loads). The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified. Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have "Area interchange control" with the "Tie Line and Loads" option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
6. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**STEADY-STATE MODELING REQUIREMENTS**

**GENERATORS**

1. All steady-state generators, including synchronous condensers and Static Var Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-
state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the XSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

**XSOURCE Table:**

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS FOR XSOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous: Detailed</td>
<td>Unsaturated sub-transient reactance ($X''_d$) [PU]</td>
</tr>
<tr>
<td>Subtransient</td>
<td></td>
</tr>
<tr>
<td>Synchronous:</td>
<td>Unsaturated transient reactance ($X'_d$) [PU]</td>
</tr>
<tr>
<td>Non-Detailed Classical</td>
<td></td>
</tr>
<tr>
<td>or Transient</td>
<td></td>
</tr>
<tr>
<td>Renewable: Wind Type 1</td>
<td>Unsaturated transient reactance ($X'_d$) of single machine [PU*]</td>
</tr>
<tr>
<td>Wind Type 2</td>
<td>OR</td>
</tr>
<tr>
<td></td>
<td>Locked rotor reactance (sum of rotor and stator leakage reactances)</td>
</tr>
<tr>
<td></td>
<td>[PU]</td>
</tr>
<tr>
<td>Renewable: Wind Type 3</td>
<td>Unsaturated transient reactance ($X'_d$) of single machine [PU]</td>
</tr>
<tr>
<td>Renewable: Inverter-</td>
<td></td>
</tr>
<tr>
<td>Based Solar PV Wind</td>
<td>$V_{rated} = \text{Rated Voltage} = 1.0$ [PU] (assumed)</td>
</tr>
<tr>
<td>Type 4</td>
<td>$I_{rated} = \text{Rated Current From GO} [PU]$</td>
</tr>
<tr>
<td></td>
<td>$X_{Source} = \frac{V_{rated}}{I_{rated}}$ [PU]</td>
</tr>
<tr>
<td>Renewable: Wind Type 5</td>
<td>Unsaturated sub-transient reactance ($X''_d$) [PU]</td>
</tr>
</tbody>
</table>

* PU values should be based on the rated terminal voltage and machine MVA base

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation. If a user model representing particular SVC
and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:
   a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used
   b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation
   c. Different development phases
      i. These representations should be combined as the phases are placed in service as applicable

OTHER DEVICES

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 110, 72, and 63.5 kV.
   Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

   If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model
bus ties using $R=0.00000 + X=0.0001$ and $B=0.00000$. These values facilitate differentiating between bus ties and other low impedance lines, utilizing the zero impedance threshold $THRSHZ$ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of $R=0.0001 + X=0.0002$ and $B=0.00000$. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – To adequately model transformers, the following parameters, at a minimum, are required:
   a. Nominal voltage of windings and bus reference to which the appropriate winding is connected
      When entering transformer data, the rated voltage for all applicable windings should be specified. For non-LTC transformers, the winding voltage should be set to the tap voltage.
      A recommended approach is to model three-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 1
      - X, or Low-Voltage, Winding = Winding 2
      - Y, or Tertiary-Voltage, Winding = Winding 3
      
      A recommended approach is to model two-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 2
      - X, or Low-Voltage, Winding = Winding 1
      
      The two-winding transformer winding map is in this order by default since PSS®E requires all two-winding transformers with Load Tap Changers (LTCs) to specify the tap bus as Winding 1. While not all LTC transformers have the tap on the X winding, this is common with most transformers.
   b. Impedance(s)
      A recommended approach to modeling transformer impedance is to set the winding MVA base to the system MVA base which is 100 MVA, entered as positive sequence data in pairwise (delta) format. Care should be taken to when entering transformer impedance data to ensure that the data entered corresponds to the appropriate base (system or winding).
   
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16 Care should be taken to enter the rated voltage, which may be different than the nominal voltage of the system for all transformer windings. There can be a difference between the rated voltage of the system and the transformer (nominal).
17 Two winding representation in PSS®E allows the user to select which bus number (from or to) the winding 1 resides.
Enter zero sequence data in the format appropriate to the connection code.

Connection codes <10:
- The zero sequence data must be entered as T-model format.

Connection codes >10:
- The zero sequence data must be entered in pairwise (delta) format.

c. Tap ratios
Depending on the PSS®E winding code used for the transformer, the setting should be either p.u. or kV. It should be noted, “tap ratio”, “winding ratio”, and “turns ratio” are synonymous.
- For transformers with no taps, use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
- For transformers with automatically adjusting, under-load tap changers (ULTC), it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
  - For parallel transformers, it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio for both transformers in order to prevent circulating VARs.
- For transformers with non-automatically adjusting, under-load tap changers (ULTC), it is recommended to use the tap ratio as set in the field.
- For transformers with no-load tap changers (NLTC), it is recommended to use the tap ratio as set in the field.
- It is recommended that Delta-Wye phase angle differences are incorporated appropriately in the models.

d. Minimum and maximum tap position limits
- Minimum and maximum tap position limits (RMIN and RMAX) shall be modeled based on transformer test report or manufacturer nameplate data.

e. Number of tap positions (for both the ULTC and NLTC)
- Under-load tap changers (ULTC) control bus, total number of tap positions, and tap setting shall be specified.
- No-load tap changers (NLTC) total number of tap positions and the tap setting shall be specified.
- Transformer tap positions are discrete. The total number of transformer tap positions is a fixed quantity and shall be entered. The maximum and minimum transformer tap positions represent the physical boundaries of the transformer’s capability to modify its winding impedance to achieve a control objective. Transformer tap changing control modes may include voltage regulation, as well as real and reactive power control. Automatically-adjusting under-load tap changing transformers (ULTC) shall specify a control mode, the bus that is being controlled, and the control limits defined by the maximum and minimum transformer tap positions.

18 It is noted that PSS®E provides transformer tap changer limit fields called VMAX and VMIN, regardless of control mode. For example, if a real power control mode is selected, the user must enter MW quantities in the VMAX and VMIN fields.
• For transformers with untapped windings, the number of tap positions shall be “99” to indicate that there are no taps. PSS®E does not allow a value of “1” to be used as a tap position.

f. Regulated bus (for voltage regulating transformers)
   • The regulated bus is the location where the transformer is regulating voltage. Typically this regulated bus is connected to a transformer winding bus.
   • A limit difference of less than 0.0125 p.u. shall not be used when entering the regulated voltage band limits (VMAX, VMIN) for an automatically adjusting, under-load tap changers (ULTC) transformer.
   • It is recommended that the voltage band limits VMAX and VMIN be no less than 0.025 p.u., to prevent toggling of the ULTC during simulation iterations.

g. In-service status
   • In-service status, set to zero (0) if the device is not in-service.

h. Vector group and Connection code
   • The vector group shall match the topological configuration of the buses representing where the windings are connected (e.g. A 115/69 kV load serving transformer with a vector group of Dyn11 must show the winding 1 bus [Delta winding] as the 115 kV bus).
   • Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.
   • The transformer core construction should be considered (shell type or core type) 20

i. Transformers Controlling Reactive Power Flow
   • The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10


20 Reference the TPL-007-1 Data Collection Template User Guide document under the Transformers section/Core Type. https://www.spp.org/spp-documents-filings/?id=197519
MVAR. Limits should accurately represent the actual operation of automatic control devices.

9. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes.

PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:

a. Real-time operational auto or manual adjustment operation of the PST.

b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.

c. Real-time operational MW flow limits (e.g. ±20 MW).

d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).

e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.

f. Applicable long-term firm transmission service levels for the PST.

11. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

12. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

13. Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

14. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.
15. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

17. Coordination of Regulating Devices – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

18. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

19. Flowgates – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

20. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

21. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

22. Static Var Systems – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service status equal to zero. In-service Static Var Systems should be modeled with an in-service status equal to one.
23. DC Transmission systems – DC transmission systems must be represented with a sufficiently detailed model to simulate its expected behavior.

24. Interchange Tolerances – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value. (Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

25. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence
1. A line whose impedance is very small as compared to that of a line connected in series with it. (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)
2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.
3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during Equivalencing.
4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.
5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.
6. Unrealistic tap changing transformer tap limits.
7. Radial system is very large.
8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switchable shunts.
   f. Remote regulation of more than one bus away.
10. Not solvable from flat start.
11. Fictitious regulation of buses.
12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
Troubleshooting

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the "From" bus and the second-named bus is taken as the "To" bus. The "From" bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

Note: The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

Balancing and Transactions

A core principal of steady-state power flow modeling\(^{21}\) is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of buses representing a model area\(^{22}\). While typically analogous to a

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\(^{21}\) The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

\(^{22}\) Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\textsuperscript{23} loads and induction machine loads to be assigned to model areas that may be different than the buses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

![Model area](image)

Figure 1. Example of interconnected model areas.

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\textsuperscript{23} ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (P\text{gen}) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

Data Owner A

Data Owner B

Source

Sink

Inter-area Bilateral transaction description

Data Owner A exports MW to Data Owner B

Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>Data Series MDWG Model - 18G</th>
</tr>
</thead>
</table>
| SPP| 1           | Area 1    | 1                 | Data Owner A         | 2         | Area 2   | 2               | Data Owner B       | ABC111 | 12/1/2013 | 3/1/2020 | X | MW
| Non SPP| 2           | Area 2    | 2                 | Data Owner B         | 1         | Area 1   | 1               | Data Owner A       | ABC111 | 12/1/2013 | 3/1/2020 | X | -MW

Figure 3. Example of Inter-area transfer (transaction).
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Responsible Entity #.
   d. From Responsible Entity Name.
   e. To Area #.
   f. To Responsible Entity #.
   g. To Responsible Entity Name.
   h. Transaction ID.
   i. Transaction Start date.
   j. Transaction Stop date.
   k. Firm or Non-Firm Transaction.
   l. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where external resource is located to the generation owner control area. If the external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area’s number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

No Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

Transaction Needed
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC's ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPP reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the SPP RTO with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:
1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamic model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code

The schedule for submission of Dynamic data and list of MDWG Dynamic models [case types] can be found on the SPP corporate website, www.spp.org.

Dynamics Data Submittal Requirements and Guidelines
1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.
   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
      a. Unit is a phantom or undesignated unit in a future year MMWG case.
      b. Unit is on standby or mothballed and not carrying load in MMWG cases.
   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.
2. All synchronous generators and condensers shall also include representations of the generator, excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
   b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.
c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.
d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), Flexible AC Transmission System (FACTS), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

6. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

7. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.
   Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

8. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

9. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

10. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

11. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.
Miscellaneous Other (MINS) Dynamic models

1. If a generator, transformer, or capacitor has in-service relay protection that operates in 10 seconds or less, then the relay models shall be submitted when available. Inverter-based generator resources shall have frequency and voltage protective relay models.

2. PSS®E Model Instance (MINS) values for “Miscellaneous Other” models should be a unique eight digit number. The first six digits should be the bus number at which the model is being applied. The last two digits should be a unique number designating a particular application of a “Miscellaneous Other” model at the bus. Under no circumstance shall a unique eight digit MINS number be repeated.

   MINS example: 59999900 VTGDCAT
   Bus number = 599999
   Unique identifier = 00
   Relay model = VTGDCAT

3. Unique MINS values are required for VTGDCAT/VTGTPAT, FRQDCAT/FROQTPAT, SAT2T, and SWCAPT relay models.

   PSS®E Miscellaneous Other (MINS) Dynamic model types:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTGDCAT/VTGTPAT</td>
<td>Under/over voltage generator bus disconnection relay.</td>
</tr>
<tr>
<td></td>
<td>Under/over voltage generator trip relay.</td>
</tr>
<tr>
<td>FRQDCAT/FROQTPAT</td>
<td>Under/over frequency generator bus disconnection relay.</td>
</tr>
<tr>
<td></td>
<td>Under/over frequency generator trip relay.</td>
</tr>
<tr>
<td>SAT2T</td>
<td>Transformer saturation model.</td>
</tr>
<tr>
<td>SWCAPT</td>
<td>Switched capacitor bank model.</td>
</tr>
</tbody>
</table>

Relay models

1. If a generator has in-service frequency and voltage protective relays that operate in 10 seconds or less, then the relay models shall be submitted when available. Inverter-based generator resources shall have frequency and voltage protective relay models. The generator frequency and voltage protective relay models in PSS®E are in the category of “Miscellaneous Other” models. See the following item regarding “Miscellaneous Other” models.

2. PSS®E Model Instance (MINS) values for “Miscellaneous Other” models should be a unique eight digit number. The first six digits should be the bus number at which the model is being applied. The last two digits should be a unique number designating a particular application of a “Miscellaneous Other” model at the bus. Under no circumstance shall a unique eight digit MINS number be repeated.

PSS®E Relay Model Types:
PROCEDURE FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.
   b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
      i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
      ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
      iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
      iv. Real and/or reactive power limits of +9999 or −9999.
   c. Checks which report abnormal values
      v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
      vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
      vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
      viii. Branches with extreme impedances or tap ratios [BRCH].
          Suggested options are:
          a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.

c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.

d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

d) Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.

ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.

a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]

b. Read in the raw data file just created. [READ]

c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]

d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].

e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)

a. Specify CONEC, CONET, and COMPILE files.

b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.
7. Compile.
9. Restart from the dynamics entry point, this time using "user dynamics".
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE]
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN].
      Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.
      ii. A tabulation of conditions at each online machine
         a) Terminal voltage
         b) Exciter output voltage
         c) Real and reactive power output
         d) Power factor
         e) Machine angle in degrees
         f) Direct and quadrature axis currents on machine base.
      iii. A diagnosis of initial conditions, either
         a) "Initial conditions check OK", or
         b) A listing of suspect initial conditions generally states whose time derivative is not "small" (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.
         iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems.
            This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.
      f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.
10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.
11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.
12. Stop simulation. Review output values in tabular and/or graphical form.
13. Validate exciter model response to a step change in set point [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
   a. Excessive overshoot
b. Sustained oscillations
c. High frequency noise (may be caused by using too long a simulation time step.)
d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately \((-1 / R)\) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.

Dynamic Data Format

PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

Non-PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

Acceptable Dynamic Model Information
The PSS®E simulation software dynamic machine models may be used as long as they are included on the NERC List of Acceptable Models for Interconnection-Wide Modeling and not identified as unacceptable models on that list. The NERC acceptable dynamic model list can be found on the NERC SAMS website ➔ SAMS Reference Materials ➔ NERC Acceptable Model List.

Significant improvements to models may occur over time and models may become obsolete, not recommended, or unacceptable models. Unacceptable models might still be available in the PSS®E software; however, those models must be replaced with more suitable current acceptable models.

User-written dynamic models will only be allowed under the following conditions:
1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes.
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment from the Data Owner to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified of request for conversion to an acceptable model by SPP or Transmission Planner.

MDWG developed a subset list of acceptable dynamic models based on the NERC acceptable dynamic model list and adheres to the guidance outlined in the MDWG Dynamic Models Guidelines document.

Dynamics Data Validation Requirements

1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).
2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator

Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template

Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready. The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE</th>
<th>Examples / Comments</th>
</tr>
</thead>
</table>

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| Change one or more parameters of a dynamics model | Bus name, unit ID, model name, parameter name, new value | No | The voltage regulator gain is changed to the value determined by test. |
| Add a new model to an existing unit | No | Yes | A stabilizer is being added to a unit which did not have one. |
| Delete a model | Bus name, unit ID, model name | No | A stabilizer is removed. |
| Replace a model with another model of the same equipment group | Bus name, unit ID, model name for deleted model. | Yes for new model. | 1. A DC exciter is replaced by a static exciter. 2. A classical machine model is replaced by a detailed model. |
| Change bus name and/or unit ID for all models of an existing unit | Old and new names; old and new unit IDs | No | |
| Change bus number | No | No | Maintain the same name and unit ID and the model data will follow automatically. |
| Add dynamic models for a new generating unit | Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type | Yes | Same requirements whether unit is at new or existing bus. |
| Remove a unit and all associated models | Bus name, unit ID | No | |

**Complete Set of Dynamics Data**
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators the positive and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Mutual Impedance

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line. Zero-sequence current is only present during ground faults, so the consideration of mutual coupling effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence...
fault current. It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.24

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSS®E, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSS®E models can be identified by checking when mutual impedance data is modeled and updated in a company’s primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final). The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the MDWG Powerflow models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company’s RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

All transformers shall have a Vector Group and corresponding Connection Code in PSS®E 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary

24 NERC Lesson Learned: Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements
analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of
the modeled sequence information prior to finalization.

Other information requested by the PC or TP – Information which the PC or TP deems necessary for
modeling purposes can be requested from Data Owners/Data Submitters.
SECTION 6: DEFINITIONS

These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner**\(^{25}\) – The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Data Submitter**\(^{4}\) – The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered a power export and a negative value is considered a power import.

---

\(^{25}\) Not a NERC functional entity
**Model Area** – The collection of model objects comprising an entity’s network and uniquely numbered in PSS®E.

**Peak Demand** – The highest demand including transmission losses for energy measured over a one clock hour period.26

**PSS®E** – Siemens PTI’s Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

**PSS®E MOD** – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

**PSS®MOD File Builder** – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS®MOD Modeling projects by comparing PSS®E models.

**Transaction (Model)** – A modeled purchase and/or sale of power.

**Non-scalable load** – Load that does not conform to the daily load duration curve.

**On-Peak (Model)** – Those hours or other periods typically considered periods of higher electrical demand.

**Off-Peak (Model)** – Those hours or other periods typically considered periods of lower electrical demand.

**Regulating device** – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

**Shortfall** – Occurs when an entity does not have enough dispatchable generation to serve the entity's load.

**Tie Line (Model)** – A circuit connecting two Model Areas.

26 Attachment AA Resource Adequacy Section 2
SECTION 7: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#,
From Area Name,
From Bus#,
From Bus Name,
From Bus kV,
To Region Name,
To Area#,
To Area Name,
To Bus#,
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
G1 (pu),
B1 (pu),
G2 (pu),
B2 (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

- In Service Date,
- Out Service Date,
- From Bus Region Name,
- From Bus Area#,
- From Bus Area Name,
- From Bus Number,
- From Bus Name,
- From Bus kV,
- To Bus Region Name,
- To Bus Area#,
- To Bus Area Name,
- To Bus Number,
- To Bus Name,
- To Bus kV,
- Tapped Side,
- CKT,
- CW,
- CZ,
- CM,
- MAG1,
- MAG2,
- Metered Side,
- NAME,
- STATUS (0,1),
- Owner 1,
- Fraction 1,
- Owner 2,
- Fraction 2,
- Owner 3,
- Fraction 3,
- Owner 4,
- Fraction 4,
- R1-2,
- X1-2,
- SBase1-2,
- WindV1,
- NomV1,
- AngV1,
- Summer Rating A1,
- Summer Rating B1,
- Summer Rating C1,
- Winter Rating A1,
- Winter Rating B1,
- Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT 1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RM1,
VMA1,
VM1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area #,
Winding 1 Area Name,
Winding 1 Bus #,
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area #,
Winding 2 Area Name,
Winding 2 Bus #,
Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area #,
Winding 3 Area Name,
Winding 3 Bus #,
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBase2-3,
R3-1,
Three Winding Transformer Data Fields - continued

X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus #1 (CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RM11,
VMA1,
VM11,
NTP 1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued
RM12,
VMA2,
VM12,
NTP2,
TAB2,
CR2,
CX2,
WindV3,
NomV3,
Ang3,
Summer Rating A3,
Summer Rating B3,
Summer Rating C3,
Winter Rating A3,
Winter Rating B3,
Winter Rating C3,
COD3,
Control Bus 3 Region,
Control Bus 3 Area Number,
Control Bus 3 Area Name,
CONT3,
Control Bus 3 Name,
Control Bus 3 KV,
RMA3,
RM13,
VMA3,
VM13,
NTP3,
TAB3,
CR3,
CX3
Two Terminal DC Tie Data Fields
In Service Date,
Out Service Date,
I,
MDC,
RDc,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (R,I),
DCVMIN,
CCCTIMX,
CCACC,
IPR REGION NAME,
IPR AREA#, 
IPR AREA NAME,
IPR Bus#, 
IPR BUS NAME,
IPR BUS Kv,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#, 
ICR AREA NAME,
ICR BUS#, 
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#, 
IFR AREA NAME,
IFR BUS#, 
IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAPR,
IP1 REGION NAME,
IP1 AREA#, 
IP1 AREA NAME,
IP1 Bus#, 
IP1 BUS NAME,
IP1 BUS Kv,
NBI,
GAMMX,
GAMMN,
RCI,
XCI,
EBASI,
TRI,
TAPI,
TMXI,
TMNI,
STPI,
ICI REGION NAME,
ICI AREA#, 
ICI AREA NAME,
ICI BUS#, 
ICI BUS NAME,
ICI BUS kV,
IFI REGION NAME,
IFI AREA#, 
IFI AREA NAME,
IFI BUS#, 
IFI BUS NAME,
IFI BUS kV,
IT1 REGION NAME,
IT1 AREA#, 
IT1 AREA NAME,
IT1 BUS#, 
IT1 BUS NAME,
IT1 BUS kV,
IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
## SECTION 8: APPENDIX II

### UTILIZED IMPEDANCE CORRECTION TABLES

| Table Number | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor | Tap or Angle | Factor |
|--------------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|--------------|--------|
| 1            | -60          | 1      | -36          | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 2            | -70          | 1      | -43          | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 3            | -70          | 1      | -43          | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 4            | -115         | 1      | -121.5       | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 5            | -40          | 1      | -28.5        | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 6            | -70          | 1      | -43          | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 7            | -180         | 1      | -150         | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 8            | -152         | 1      | -121.5       | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 9            | -40          | 1      | -28.5        | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
| 10           | -25          | 1      | -15          | 0.366  | -24.4        | 0.024  | 6.5          | 0.124  | 6.5          | 0.124  | 12.4         | 0.154  | 24.4         | 0.227  | 56          | 0.536  | 80          | 1      |
SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice

Designating MOD-032-1 Data Submittal Assignment

On this ______ day of __________, 20____, and ________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following:

On __________________, 20____, Data Owner, and __________________________, Data Submitter, entered into an agreement through which ______________________ has agreed to submit on behalf of ______________________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

________________________________________________________________________________________________________________
________________________________________________________________________________________________________________
________________________________________________________________________________________________________________

The accuracy of the data is the responsibility of the Data Owner. This notice does not shift the compliance obligation from the Data Owner to the Data Submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER:    SPP hereby acknowledges receipt of this notice.
    By: ______________________________    By: ______________________________
    Printed Name: _____________________   Printed Name: _____________________
    Title: _____________________________   Title: _____________________________
    Date: _______________     Date: _______________

On behalf of DATA SUBMITTER:
    By: ______________________________
    Printed Name: _____________________
    Title: _____________________________
    Date: ______________

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<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP-approved Transmission System Upgrade</td>
<td>Material transmission changes that have not been acknowledged by SPP, and may be included in model sets.</td>
<td>Approved</td>
<td>SPP Projects must contain an area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number. Example Prj/Idv Name: 822_NextEra_Add_Blue_Cloud_Wind_GEN-20YY-###.prj</td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
<td>Material transmission changes that have not yet been submitted to SPP for inclusion in the model sets.</td>
<td>Requested</td>
<td>See SPP Project Type &amp; Status to represent transmission changes expected to be implemented in the future, but are not yet, or will not be, part of any SPP planning processes under Attachment O to the SPP GATT. Do not use this MOD Project Type to submit speculative changes to the transmission model that simply correct basecase system conditions (See MOD Project Type &quot;System Intact Alteration&quot;).</td>
</tr>
<tr>
<td>Attachment AQ</td>
<td>Material transmission changes that have not affected reliability or transmission service.</td>
<td>Approved</td>
<td>Use changes and transmission changes, including upgrades and changes to normally-operational topology, associated with the approved Attachment AQ to represent transmission changes in accordance with the approved Attachment AQ. Example Prj/Idv Name: 525_WFEC_Midwest-Franklin_Rebuild_NTC2002 OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj</td>
</tr>
<tr>
<td>Generation Interconnection</td>
<td>Generation changes and transmission changes, including upgrades that may have been included in the executed IA, associated with the approved Attachment AQ.</td>
<td>Approved</td>
<td>Use changes and transmission changes, including upgrades and changes to normally-operational topology, associated with the approved Attachment AQ to represent transmission changes in accordance with the approved Attachment AQ. Example Prj/Idv Name: 525_WFEC_Midwest-Franklin_Rebuild_NTC2002 OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-Month-###.prj</td>
</tr>
<tr>
<td>Network Status</td>
<td>Changes to the existing SPP Transmission System network topological status only (both placed out-of-service or returned to service).</td>
<td>Update</td>
<td>Applyable equipment must already be included in the MOD database (constructed, pre-existing) to be placed in- or out-of-service. Projects with this status will be immediately committed to the MOD base case for review.</td>
</tr>
<tr>
<td>Modeling/Correction</td>
<td>Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD model data.</td>
<td>Update</td>
<td>Projects with this status will be immediately committed to the MOD base case for review. Projects with this status will not be applied to any models except those models submitted to MMWG.</td>
</tr>
<tr>
<td>System Instal Alterations</td>
<td>Changes to the transmission model necessary to correct basecase system status voltage (e.g., to conform to MMWG voltage criteria, thermal criteria violations, or other basecase condition modifications (e.g., addition of an exploratory generating unit which provided resource for balancing).</td>
<td>Update</td>
<td>Projects with this status will be immediately committed to the MOD base case for review. Projects with this status will not be applied to any models except those models submitted to MMWG.</td>
</tr>
</tbody>
</table>

---

**SECTION 10: APPENDIX IV SPP MODEL ON DEMAND (MOD) MATRIX**

**SPP MOD Project Type/Status Matrix**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Description</th>
<th>Applied to this Model Set</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP-approved Transmission System Upgrade</td>
<td>Material transmission changes that have not been acknowledged by SPP, and may be included in model sets.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
<td>Material transmission changes that have not yet been submitted to SPP for inclusion in the model sets.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachment AQ</td>
<td>Material transmission changes that have not affected reliability or transmission service.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation Interconnection</td>
<td>Generation changes and transmission changes, including upgrades that may have been included in the executed IA, associated with the approved Attachment AQ.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Table Notes**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Description</th>
<th>Applied to this Model Set</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP-approved Transmission System Upgrade</td>
<td>Material transmission changes that have not been acknowledged by SPP, and may be included in model sets.</td>
<td>Approved</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
<td>Material transmission changes that have not yet been submitted to SPP for inclusion in the model sets.</td>
<td>Requested</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Attachment AQ</td>
<td>Material transmission changes that have not affected reliability or transmission service.</td>
<td>Approved</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generation Interconnection</td>
<td>Generation changes and transmission changes, including upgrades that may have been included in the executed IA, associated with the approved Attachment AQ.</td>
<td>Approved</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
SECTION 11: APPENDIX VII GMD/GIC DATA COLLECTION TEMPLATE USER’S GUIDE

GEOMAGNETIC DISTURBANCE MODELING DATA

Additional modeling data is necessary to supplement the MDWG steady-state models to support geomagnetic disturbance (GMD) analysis. The SPP GMD Model Set combines GMD-related system information (described below) with the MDWG AC-equivalent representation of the SPP transmission system. This composite of modeling data yields a DC-equivalent representation used to calculate geomagnetically-induced current (GIC) flows. These GIC magnitudes can then be applied to the MDWG AC-equivalent model to yield steady-state effects to System voltages and transformer MVAR losses. Appropriate simulations of GMD effects to the BES cannot be achieved without the incorporation of the following modeling information:

Substation Data
Substation modeling data encompasses geographical information related to power system topological information, as represented by the bus-branch model.

**Bus Number (Planning Model):** This is the actual bus from the Planning Model. This bus will be associated with a substation on the Substations sheet.

**Substation Bus Number (Planning Model):** Choose one bus to serve as the substation reference. In other words, the bus number annotated in this field will serve as the geographic reference for the entire substation. The recommendation is for the model Data Submitter to pick the highest voltage bus in a station to serve as this reference.

**Substation DC Grounding Resistance (Ohms):** This can be a measured, calculated, or assumed value for the grounding resistance in Ohms. Caution: do not convert this grounding resistance to per unit Ohms; retain the actual Ohmic quantity. In the unlikely event that a substation/switchyard is ungrounded, the model Data Submitter may enter “-1” here, not zero. Measured values come from ground grid testing, while calculated values are derived from detailed design modeling. When a substation is commissioned or periodic maintenance is performed, grounding integrity or ground grid data is typically collected.

**Grounding Resistance (Method):** This field indicates how the grounding resistance information was obtained.

**Geographic Latitude (decimal degrees):** This latitude will be used for all buses assigned to this station on the “Buses” sheet. Given that the entire SPP footprint is in the Northern Hemisphere, only positive decimal degree values are acceptable for latitude.
Geographic Longitude (decimal degrees): This longitude will be used for all busses assigned to this station on the "Busses" sheet. Caution: longitudes to the west of the Prime Meridian are between 0 and -180°. Given that the entire SPP footprint falls between the 85th west meridian and the 115th west meridian, only negative decimal degree values are acceptable for longitude.

Earth Model (Name): This field assigns the one-dimension earth conductivity model to the geographical location of the substation reference bus. The earth model is based upon the standard earth conductivity models developed by the United States Geological Survey (USGS). The following table shows the cross-reference between the USGS reference and the software code that should be placed in the "Earth Model Name" field. On the "1D Earth Model Reference" sheet, a tool is provided to assist in determining the proper earth model by latitude and longitude.

<table>
<thead>
<tr>
<th>USGS Earth Conductivity Model</th>
<th>Equivalent to:</th>
<th>Siemens/PTI software code (enter into the &quot;Earth Model Name&quot; field)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK-1A</td>
<td>AK1A</td>
<td>Adirondack Mountains-1A</td>
<td></td>
</tr>
<tr>
<td>AK-1B</td>
<td>AK1B</td>
<td>Adirondack Mountains-1B</td>
<td></td>
</tr>
<tr>
<td>AP-1</td>
<td>AP1</td>
<td>Appalachian Plateaus</td>
<td></td>
</tr>
<tr>
<td>AP-2</td>
<td>AP2</td>
<td>Northern Appalachian Plateaus</td>
<td></td>
</tr>
<tr>
<td>ATLANTIC</td>
<td>ATLANTIC</td>
<td>Northeastern Atlantic Coast, Nova Scotia</td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>BC</td>
<td>British Columbia (BC)</td>
<td></td>
</tr>
<tr>
<td>BR-1</td>
<td>BR1</td>
<td>Northwest Basin and Range</td>
<td></td>
</tr>
<tr>
<td>CL-1</td>
<td>CL1</td>
<td>Colorado Plateau</td>
<td></td>
</tr>
<tr>
<td>CO-1</td>
<td>CO1</td>
<td>Columbia Plateau</td>
<td></td>
</tr>
<tr>
<td>CP-1</td>
<td>CP1</td>
<td>Coastal Plain (South Carolina)</td>
<td></td>
</tr>
<tr>
<td>CP-2</td>
<td>CP2</td>
<td>Coastal Plain (Georgia)</td>
<td></td>
</tr>
<tr>
<td>CS-1</td>
<td>CS1</td>
<td>Cascade-Sierra Mountains</td>
<td></td>
</tr>
<tr>
<td>FL-1</td>
<td>none</td>
<td>Florida</td>
<td></td>
</tr>
<tr>
<td>IP-1</td>
<td>IP1</td>
<td>Interior Plains (North Dakota)</td>
<td></td>
</tr>
<tr>
<td>IP-2</td>
<td>IP2</td>
<td>Interior Plains</td>
<td></td>
</tr>
<tr>
<td>IP-3</td>
<td>IP3</td>
<td>Interior Plains (Michigan)</td>
<td></td>
</tr>
<tr>
<td>IP-4</td>
<td>IP4</td>
<td>Interior Plains (Great Plains)</td>
<td></td>
</tr>
<tr>
<td>MID-ATL</td>
<td>PT-1</td>
<td>Mid-Atlantic</td>
<td></td>
</tr>
<tr>
<td>NE-1</td>
<td>NE1</td>
<td>New England</td>
<td></td>
</tr>
</tbody>
</table>
Transformers

The Transformers sheet is intended to collect all of the information necessary to properly determine the magnitude of GIC that will arise within a given transformer. It is important to note that transformer winding resistance data collected from transformer specification sheets or test reports may represent the total resistance of the three phases combined.

While well known to model Data Submitters, the convention for MDWG model data is consistent with most load flow software that requires data be submitted per phase. Therefore, any combined three-phase transformer winding resistance data must be divided by three prior to submitting quantities. Similarly, when DC resistances of transformer windings are unknown (estimated values should only be used when data are unavailable), a reasonable assumption is to substitute actual data with 50% of the per phase copper loss resistance. It is noted that total copper loss resistance may be converted to per phase by dividing by three, and all values should be entered as Ohms, not in per unit base. For example, transformer test reports typically report the total copper loss of a transformer, derived from a short-circuit test\(^2\), either as a total copper loss power [W] or as the total winding resistance [ohms] calculated from the total copper loss power. In either case, these quantities represent the total copper loss effects of three windings combined and must be divided by three to properly reflect the per phase resistance. The model Data Submitter is expected to provide the following data:

**Core Type:** This indicates the number of cores in transformer core design and is used to calculate transformer reactive power loss from GIC flowing in its winding. This field is only used by the software when a K-factor quantity is not specified by the model Data Submitter for the transformer.

---

\(^2\) Also known as a transformer impedance test, a typical transformer short-circuit test is performed by shorting the low-voltage winding and increasing the high-voltage winding voltage until transformer rated current is observed in the high-voltage winding. This test recognizes that core loss is negligible, yielding the resistive losses in the primary winding circuit.

<table>
<thead>
<tr>
<th>USGS Earth Conductivity Model</th>
<th>Equivalent to:</th>
<th>Siemens/PTI software code (enter into the “Earth Model Name” field)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OZARK</td>
<td>CP-2</td>
<td>CP-2</td>
<td>Ozarks</td>
</tr>
<tr>
<td>PB-1</td>
<td>PB1</td>
<td>Pacific Border (Willamette Valley)</td>
<td></td>
</tr>
<tr>
<td>PB-2</td>
<td>PB2</td>
<td>Pacific Border (Puget Lowlands)</td>
<td></td>
</tr>
<tr>
<td>PRAIRIES</td>
<td>PRARIES</td>
<td>Alberta (AB), Saskatchewan (SK), Manitoba (MB)</td>
<td></td>
</tr>
<tr>
<td>PT-1</td>
<td>PT1</td>
<td>Piedmont</td>
<td></td>
</tr>
<tr>
<td>RM</td>
<td>CL-1</td>
<td>Rocky Mountain</td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>PB-1</td>
<td>SHIELD</td>
<td></td>
</tr>
<tr>
<td>SL-1</td>
<td>SL1</td>
<td>St. Lawrence Lowlands</td>
<td></td>
</tr>
<tr>
<td>SU-1</td>
<td>SU1</td>
<td>Superior Upland</td>
<td></td>
</tr>
</tbody>
</table>
In other words, if you know the K-factor for the transformer (or have a better assumption), enter the quantity in the "GIC Reactive Loss Factor (K-factor)" field and it diminishes the importance of the "Core Type" field. Otherwise, the values for this field are limited to:

<table>
<thead>
<tr>
<th>Code</th>
<th>Core Design Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Three-phase shell configuration</td>
</tr>
<tr>
<td>0</td>
<td>Unknown core design</td>
</tr>
<tr>
<td>1</td>
<td>Three separate single phase cores design</td>
</tr>
<tr>
<td>3</td>
<td>Three phase, 3-legged core configuration</td>
</tr>
<tr>
<td>5</td>
<td>Three phase, 5-legged core configuration</td>
</tr>
<tr>
<td>7</td>
<td>Three phase, 7-legged core configuration</td>
</tr>
</tbody>
</table>

If the core configuration is unknown, stating as such in the Core Type field is acceptable. When this is done, the software will make an assumption for K-factor based upon the voltage level of the highest winding voltage of that transformer. All transformers in the SPP MDWG model series are expected to have vector groups defined, so that T-modeling of transformers in the DC network is permitted.

Connection Code (CC): This is the field for the Data Submitter to update the Connection Code shown in the Existing Connection Code (CC) field, if warranted. This field is included because experience has shown that prior model-building efforts may not have focused on this data, but it is critical to GIC modeling. It is suggested that the model Data Submitter review vector group and winding order to ensure proper CC submittal.

Vector Group: This is key data required to properly model the grounding characteristics of a transformer. While potentially misleading, most load flow software packages embed the transformer per phase winding configuration information under short-circuit data category. The confusing aspect is that winding configuration is meaningful in situations other than under short-circuit conditions; for example, with GIC that arise from GMD. As a reminder, the Connection Code data contained within the load flow model representation embodies concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation.

GIC Reactive Loss Factor (K-factor): The K-factor is an important aggregated assumption that helps formulate the transformer sensitivity to half-cycle saturation that arises from the contribution of GIC. In other words, the K-factor indicates a measure of increased reactive power losses in the transformer when subjected to GICs. The units of K-factor are MVAR per Ampere; the larger the K-factor the larger expected reactive power losses in the transformer. K-factor is used to calculate additional transformer reactive power losses according to:

\[ Q_{\text{loss}} = \text{Effective GIC Winding Current} \times K-\text{Factor}. \]
There is much debate in industry about how to measure, calculate, and assume values for K-factor. In general, if a K-factor is not specified on a transformer data sheet or in test reports, the following table annotates appropriate assumed values. It is noted that the following assumptions for K-factor are consistent with those integrated into the Siemens/PTI software:

<table>
<thead>
<tr>
<th>Core Type Code</th>
<th>Highest Winding kV</th>
<th>K-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Any</td>
<td>0.33</td>
</tr>
<tr>
<td>0</td>
<td>&lt;=200 kV</td>
<td>0.6</td>
</tr>
<tr>
<td>0</td>
<td>&gt; 200kV, &lt;= 400kV</td>
<td>0.6</td>
</tr>
<tr>
<td>0</td>
<td>&gt; 400kV</td>
<td>1.1</td>
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<tr>
<td>1</td>
<td>Any</td>
<td>1.18</td>
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<tr>
<td>3</td>
<td>Any</td>
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<td>5</td>
<td>Any</td>
<td>0.66</td>
</tr>
<tr>
<td>7</td>
<td>Any</td>
<td>0.66</td>
</tr>
</tbody>
</table>

DC Resistance of From, To, and Tertiary Windings (Ohms/Phase): The preferred value is measured, typically derived from a transformer specification sheet or test report. This data should be the measured DC resistance of single winding at nominal tap and adjusted to 75 °C. Caution: do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

From, To, and Tertiary Windings Grounding Resistance (Ohms): The preferred value is measured or calculated, typically derived from a ground grid design, transformer test report, or other test report. This data should be the measured DC resistance of single winding at nominal tap and adjusted to 75 °C. Caution: do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

Blocking Device Status (From, To, and Tertiary Windings): Indicate whether a GIC blocking device is installed and is operational on the From winding in this field. GIC blocking devices on transformer windings are rare.

DC Resistance of From, To, and Tertiary Windings Blocking Device (Ohms): Currently, most load flow software tools that support a GIC analysis module assume that if a blocking device is installed and active, that the DC resistance of that block is infinite. In other words, the winding is either blocked from participating in GIC flow or not. It is expected that in future versions GIC analysis modules that software will support an actual DC resistance for the blocking device to more precisely model GIC flow through the transformer winding. Input the known DC resistance of the blocking device in Ohms, if known.
Transformer Model in DC Network: Entered as 0 to represent the transformer according to its vector group, or entered as 1 to represent the transformer as a T-model. **Important note:** given that all transformers in the SPP MDWG model series are expected to have vector groups defined, the model Data Submitter should avoid entering 1 in this field. In future revisions of the MDWG model data collection, this field may be eliminated. However, due to an outstanding PSS®E software ambiguity for symmetric phase shifting transformers, this field is retained.

Symmetric phase shifting transformers modulate real power flow, typically to a narrow specified range. These are represented in the load flow model by two-winding transformer representations that utilize the “MW symmetrical PAR” or “MW asymmetrical PAR” control mode. These transformers should be modeled as the YNa vector group with Connection Codes (CC) 9 or 19, reflecting that the winding 1 impedance represents the zero sequence impedance of the regulating transformer, the winding 2 impedance represents the zero sequence impedance of the series transformer, and the shunt branch represents the tertiary winding impedance. If the symmetric phase shifting transformer is entered this way, the "Transformer Model in DC Network" (TMODEL) should be entered as 0. However, in those rare cases when a vector group is not specified for the symmetric phase shifting transformer, the PSS®E software needs to establish a default for the transformer T-model representation in DC analysis. This is accomplished by entering the “Transformer Model in DC Network” (TMODEL) as 1.

**Shunts**

The Shunts sheet is intended to collect information necessary for modeling direct paths to ground that contribute to the magnitude of GIC flow on the power system. There are two key observations that need to be considered when submitting shunts data for MDWG model data collection. First, Switch Shunt capacitor devices are not considered by GIC analysis software. This is due to the expectation that capacitive shunts are GIC blocks and inductive devices would be intentionally placed out-of-service so as to not exacerbate GIC during GMD events. Second, line reactor devices are very important for modeling GIC. However, the practice of representing line reactors is inconsistent amongst model builders, where some explicitly model line reactor shunts at buses in the transmission line path, while others incorporate the impedance of the line shunt into the data record of the transmission line branch itself. It is important to confirm how line shunts are being modeled. The model Data Submitter is expected to provide the following data:

**From, To Bus Number (Planning Model):** Self-explanatory; where the fixed shunt is located. In the case where the line shunt is modeled as part of the transmission line branch, enter the bus number of the branch terminal end that is closest to the physical location of the line reactor. If line reactors reside at both ends of the branch, make two separate line item entries (e.g., separate rows) to reflect two separate line reactors.

**Line or Bus (Planning Model):** Enter the method of modeling the shunt device, as either explicitly at a bus or as part of a line (branch).

**Located at which end (From, To, or Both):** For line shunts modeled as part of the transmission line branch, enter at which terminal ends the line reactor is installed. Otherwise, leave this field blank.
Winding Connection Type: This information is not currently used as part of the analysis, but may be relevant in future assessments. Enter the winding configuration as Wye, Grounded-Wye, or Delta. This information should be annotated on the shunt specification sheet or as part of a test report.

Shunt DC Resistance (Ohms/Phase): The preferred value is measured, typically derived from the shunt specification sheet or test report. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

Shunt Grounding Resistance (Ohms): The preferred value is measured or calculated, typically derived from a ground grid design, shunt test report, or other test report. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Branch**

The Branch sheet is intended to reflect the characteristics of the transmission lines that serve as the current-carrying conductors participating in the varying magnetic field, giving rise to GIC. It is noted that most of the information for transmission lines is already part of load flow models. The model Data Submitter is expected to provide the following data:

Branch Resistance (pu): Most branch resistances are known in per unit, so an automatic conversion to ohms per phase is included here. The ohms per phase quantity can be entered explicitly in the DC Resistance cell or, if Branch Resistance (pu) is left as zero, the GIC module will use the AC branch resistance already in load flow model. It is important to note: this “Branch Resistance” field refers to the DC branch resistance that will characterize the transmission line in the DC model representation for GIC analysis. For the purpose of the MDWG model data collection, all transmission line conductor DC resistances shall be entered at 50 °C.

For an identical temperature, transmission line branch per phase resistances vary slightly between DC resistance and AC resistance. However, for large diameter transmission line conductors, the difference between AC and DC resistances may exceed 10%, at a common temperature. This is especially important when considering whether a transmission line employs bundled conductors. For the purpose of MDWG model data collection, it is acceptable to use the AC branch resistance already in the load flow model, if the AC resistance is based on 50 °C or less. However, care must be taken when using AC resistances as approximations of the DC resistance, especially when the AC resistance is based on temperatures greater than 50 °C. While conductor resistivity increases approximately linearly with temperature between 20 °C to 75 °C, the difference between DC and AC resistances may vary non-linearly with temperature given other transmission line characteristics, leading to significant differences in resistance. In other words, knowing that transmission line AC resistances are often entered into the load flow models at 25 °C, using this AC resistance as a conservative approximation for DC resistance is acceptable. However, any AC resistance entered into...
the load flow model using temperatures greater than 50 °C must be corrected to 50 °C prior to using the quantity as the approximation for DC resistance.

Ultimately, to perform a conservative study of GMD effects, the smaller the transmission line DC resistance, the larger the GIC that will be developed. Therefore, DC resistances entered at 50 °C are preferred. AC resistances corrected to and entered at 50 °C or less are an acceptable alternative.

**Real part of total branch GMD-induced electric field (volts):** This field is intended to allow a particular branch to experience a higher or lower induced electric field than the uniform field applied to other branches. In other words, if there is a reason to expect a particular transmission line will experience more or less induced field during a benchmark GMD event (line length times the TPL-007-3 reference geoelectric field of 8V/km), enter the alternative real-part electric field in volts. **Caution:** do not enter zeros into this field unless the transmission line is not intended to participate in the development of an electric field due to GMD. Rare examples of when this may be the case include buried or undersea transmission cable. Leave this field blank to apply the uniform electric field automatically.

**Imaginary part of total branch GMD-induced electric field (volts):** This field is intended to allow a particular branch to experience a higher or lower induced electric field than the uniform field applied to other branches. In other words, if there is a reason to expect a particular transmission line will experience more or less induced field during a benchmark GMD event (line length times the TPL-007-3 reference geoelectric field of 8V/km), enter the alternative imaginary-part electric field in volts. **Caution:** do not enter zeros into this field unless the transmission line is not intended to participate in the development of an electric field due to GMD. Rare examples of when this may be the case include buried or undersea transmission cable. Leave this field blank to apply the uniform electric field automatically.

**Loads**

**Note:** loads for GMD data submittal are expected to be exceptions and are uncommon! Albeit rare, the possibility exists that a relevant load may be connected at EHV/HV levels that offers a ground path for GIC. Likewise, it may be desirable for a Data Submitter to include data for a solidly-grounded load direct-served through an EHV/HV autotransformer (uncommon), such as with a large industrial load. All loads do not need to be entered into the Loads sheet! The Loads sheet is intended to collect information necessary for modeling the rare direct paths to ground introduced due to load connections that contribute to the magnitude of GIC flow on the power system. The model Data Submitter is expected to provide the following data:

**Winding Connection Type:** This information is not currently used as part of the analysis, but may be relevant in future assessments. Enter the winding configuration as Wye, Grounded-Wye, or Delta. For loads with a dedicated step-down transformer, this information may be annotated on the step-down transformer specification sheet or as part of a test report for the primary winding (non-autotransformer) or the primary-secondary autotransformer winding configuration.

**Load DC Resistance (Ohms/Phase):** The Data Submitter should take care when entering this value. Remember, for autotransformers, the common winding (primary and secondary) is likely grounded. When determining the load DC resistance, consider that the actual impedance of the load to ground is connected to the secondary in parallel with the tapped common winding. The preferred value is
measured DC resistance of single phase and adjusted to 75 °C, but the common winding to ground resistance may be a suitable proxy for DC analysis. **Caution**: do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Load Grounding Resistance (Ohms)**: The preferred value is measured or calculated, typically derived from the step-down transformer test report indicating the transformer neutral grounding. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution**: do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.
MOD-032-1 – ATTACHMENT 1

The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

### steady-state
(Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)

<table>
<thead>
<tr>
<th>1. Each bus [TO]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. nominal voltage</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Aggregate Demand*[2] [LSE]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. real and reactive power*</td>
</tr>
<tr>
<td>b. in-service status*</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Generating Units*[3] [GO, RP (for future planned resources only)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide)</td>
</tr>
</tbody>
</table>

### dynamics
(If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)

<table>
<thead>
<tr>
<th>1. Generator [GO, RP (for future planned resources only)]</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>2. Excitation System [GO, RP (for future planned resources only)]</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>3. Governor [GO, RP (for future planned resources only)]</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>4. Power System Stabilizer [GO, RP (for future planned resources only)]</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>5. Demand [LSE]</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>6. Wind Turbine Data [GO]</th>
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<table>
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<th>7. Photovoltaic systems [GO]</th>
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<th>8. Static Var Systems and FACTS [GO, TO, LSE]</th>
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<th>9. DC system models [TO]</th>
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<th>10. Other information requested by the Planning Coordinator or</th>
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### short circuit

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<tr>
<th>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</th>
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<tbody>
<tr>
<td>a. Positive Sequence Data</td>
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<td>b. Negative Sequence Data</td>
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<td>c. Zero Sequence Data</td>
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<th>2. Mutual Line Impedance Data [TO]</th>
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<th>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</th>
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29 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
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<tr>
<th>Data in the same manner as that required for aggregate Demand under item 2, above.</th>
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<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
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<tr>
<td>e. machine MVA base</td>
</tr>
<tr>
<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
</tr>
<tr>
<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
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<tr>
<td>h. in-service status*</td>
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4. AC Transmission Line or Circuit [TO]
   a. impedance parameters (positive sequence) |
   b. susceptance (line charging) |
   c. ratings (normal and emergency)* |
   d. in-service status* |

5. DC Transmission systems [TO]

6. Transformer (voltage and phase-shifting) [TO]
   a. nominal voltages of windings |
   b. impedance(s) |
   c. tap ratios (voltage or phase angle)* |
   d. minimum and maximum tap position limits |
   e. number of tap positions (for both the ULTC and NLTC) |
   f. regulated bus (for voltage regulating transformers)* |
   g. ratings (normal and emergency)* |
   h. in-service status* |

Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. admittances (MVars) of each capacitor and reactor
   b. regulated voltage band limits* (if mode of operation not fixed)
   c. mode of operation (fixed, discrete, continuous, etc.)
   d. regulated bus* (if mode of operation not fixed)
   e. in-service status*

8. Static Var Systems [TO]
   a. reactive limits
   b. voltage set point*
   c. fixed/switched shunt, if applicable
   d. in-service status*

9. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GD, LSE, TO, TSP]
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. Moses to include language about aux load in the ITP models in the posting email.

Motions:

1. Jason Shook motioned to approve the agenda as presented. Steve Hohman seconded the motion.

2. Jason Shook moves to approve the January 22, 2020 meeting minutes as presented in the background meeting materials. Jerad Ethridge seconded the motion. The motion passed with one abstention.

3. Reené Miranda moves to approve the manual language for “The capability amounts for PMAX, PMIN, QMAX, QMIN should not be changed until the unit is fully decommissioned”. Scott Schichtl second. The motion passed unanimously.

4. Jason Shook motioned to adjourn the meeting. Andy Berg seconded the motion. The motion passed unanimously.
**MDWG MINUTES**  
February 13, 2020

**SOUTHWEST POWER POOL**  
MODEL DEVELOPMENT WORKING GROUP MEETING

February 13, 2020 9:00 am – 12:00 pm (CST)  
Conference Call

**MINUTES**

**AGENDA ITEM 1 – ADMINISTRATIVE ITEMS**

**AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT**

SPP MDWG Chair, Nate Morris, called the meeting to order at 9:33 am with Quorum. SPP Staff Secretary, Sunny Raheem, read the anti-trust statement to the group.

**AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES**

The following members attended or represented by proxy:

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<thead>
<tr>
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<th>Proxy</th>
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<tr>
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<td></td>
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<tr>
<td>Jerad Ethridge</td>
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<td></td>
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<td>Jerry Bradshaw</td>
<td>YES</td>
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<td>Joe Fultz</td>
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<td>Grand River Dam Authority</td>
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<td>Jeremy Harris</td>
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<td>KCP&amp;L and Westar, Evergy Companies</td>
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<td>Jason Hofer</td>
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<td>Steve Hohman</td>
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<td>Holli Krizek</td>
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<td>Western Area Power Administration</td>
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<td>Jordan Lamb</td>
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<td>Alex Mucha</td>
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<td>Scott Schichtl</td>
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<td>Jason Shook</td>
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<td>Liam Stringham</td>
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<td>Sunny Raheem</td>
<td>YES</td>
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<td>Southwest Power Pool, Inc., MDWG Secretary</td>
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Additional Guests:

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<tr>
<td>Jeremy Severson</td>
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<tr>
<td>Conner Sweet</td>
<td>City Utilities of Springfield</td>
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<tr>
<td>Tyler Baxter</td>
<td>Cornbelt Electric Power</td>
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<td>Pallab Datta</td>
<td>Evergy Companies</td>
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<tr>
<td>Dona Parks</td>
<td>Grand River Dam Authority</td>
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<tr>
<td>Bryan Haslinger</td>
<td>ITC Transco</td>
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<td>John Payne</td>
<td>Kansas Electric Power Cooperative</td>
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<tr>
<td>Edin Terzic</td>
<td>Lincoln Electric System</td>
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<tr>
<td>Ryan Benton</td>
<td>Midwest Energy</td>
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<tr>
<td>Armin Sehic</td>
<td>Municipal Energy Agency of Nebraska</td>
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<tr>
<td>Daryl Huslig</td>
<td>Oklahoma Gas and Electric</td>
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<td>Tom Mayhan</td>
<td>Omaha Public Power District</td>
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<tr>
<td>Becca McCann, Brooke Keene,</td>
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<td>Hummad Malhi</td>
<td>Western Farmers Electric Cooperative</td>
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<tr>
<td>Ben Hammer, Brianna Haug, Chris</td>
<td>Western Area Power Administration</td>
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</table>
AGENDA ITEM 1E – AGENDA REVIEW

Nate Morris asked the group if they had a chance to review the agenda and if the group has any modifications to the agenda. The group did not voice any modifications.

**Motion:** Jason Shook motioned to approve the agenda as presented. Steve Hohman seconded the motion.

Material: FEB13_Attach1 - 1e. MDWG Meeting Agenda 20200213.docx

AGENDA ITEM 1F – PREVIOUS MEETING MINUTES

Nate Morris asked the group if they had any modification to the January 22, 2020 meeting minutes. There was no additional discussion or feedback to the minutes from the group.

**Motion:** Jason Shook moves to approve the January 22, 2020 meeting minutes as presented in the background meeting materials. Jerad Ethridge seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed with one abstention. Reené Miranda provided the following comments for his abstention.

Reené Miranda: “Reason for my abstention of the January 22, MDWG meeting minutes is that I was not present at the meeting.”

Material: FEB13_Attach2 - 1f. Previous January 22, 2020 Meeting Minutes.pdf

AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Sunny Raheem presented an overview of the action items and briefly discussed recently completed items. Sunny reviewed staffs’ comments as denoted in red font since the last meeting for in-progress action items.

Michael Odom provided the group an update for action item 73. Michael mentioned staff identified that the short circuit data in EDST is used during the merge process of the short circuit models regardless of whether AECI submits data.

GRDA responded that this satisfies them to know that the source of data is from EDST rather than AECI. Staff suggested the action item be marked as complete. Nate mentioned that if other people have questions about the short circuit data they can reach out to Michael directly. Dona Parks from GRDA agreed the action item could be marked as complete. A member of the group asked if the powerflow data during the merge process is also from EDST. Staff confirmed both powerflow and short circuit data during the merge is honored from EDST.
Michael Odom provided an update for action item 75 pertaining to updating the manual task force meeting time and public calendar. Michael mentioned some of the task force meetings will be shifted or maybe once a month calls since some of the meetings conflict with the MDWG meetings. Michael mentioned there are many discussion topics for the MDWG manual task force for the upcoming model build.

Scott Rainbolt asked about action item 72 pertaining to SPP Staff’s response for evaluate the age and condition data collection based on the 2019 ITP constraints. Sunny Raheem answered that the modeling team has communicated the 2019 ITP constraints evaluation recommendation the SPP ITP teams. However, additional follow is required before staff can be provide an answer. Sunny mentioned there is a concern about the impact to the portfolio if an issue is uncovered. Scott recommended the action item be marked as in-progress and not completed. Staff agreed to the action item 72 status update.

AGENDA ITEM 3 – SPP DYNAMIC LOAD TASK FORCE UPDATE

Scott Jordan gave a brief update on the recent SPP Dynamic Load Task Force (DLTF) activities. Scott discussed certain breaker-breaker contingency testing on a few cases with the additional composite dynamic loads. Scott mentioned the case worked fine with the contingency analysis with the composite load models in the case. Scott mentioned the DLTF would bring some language for the MDWG manual on composite load models in the next few months.

Chris Colson commented that part of the conversation MDWG needs to be cognizant of is how MDWG will get some of the Distributed Energy Resource (DER) information. Chris urged the group to be aware that the DER information collecting effort is coming quick and some policies will have to be written.

AGENDA ITEM 4 – MDWG GENERATION DISPATCH FG UPDATE

Steve Hohman asked Lottie Richardson to summarize some of the meeting minutes from the previous generation dispatch meeting. Lottie provided a brief description of the topics from the last meeting. Chris Colson provided a summary of the “super balance area” proposal he presented at the last focus group meeting. Chris mentioned the next step is to formulate an ECDI file for all units in SPP using generic heat rate data to demonstrate that a super BA economic dispatch is a better way to approach the MDWG model dispatch.

Steve highlighted the TWG action item 186 to address model reduction was kept open. Steve mentioned the NEDTF discussions that could affect the planning model dispatch assumptions. Steve mentioned the group will discuss whether ECDI or block dispatch should be used and that the process will have to be transparent to data submitters and owners.

Lottie then encouraged everyone to join them on the generation dispatch meeting to learn and provide input. Sunny then asked Lottie to go through the draft agenda for the next focus group; Lottie stepped through some items of the items at the next meeting.
AGENDA ITEM 5 – 2020 SERIES MDWG MODEL UPDATES

AGENDA ITEM 5A – POWERFLOW

Moses Rotich provided the group an update on the 2020 series MDWG powerflow models. Moses reminded the group the EDST survey is still out for feedback and he would encourage members to participate in that effort. Moses mentioned a MOD file builder patch was communicate via email yesterday. Moses communicated the posting of the updated modeling contact spreadsheet for feedback.

Moses reminded the group of the MDWG manual Letter of Notice should be provided if a data submitter is providing data on behalf of another data owner. Reené Miranda asked if mentioned SPS is not the Transmission Planner for a Generator Owner (GO) facility. In this scenario should SPS provide data updates if SPS is aware of the GO data update. Staff mentioned they would like to be aware of the data update so SPP can follow up with the GO as part of the MOD-032-1 data submission. Andy Berg mentioned MRES as the Transmission Owner should not have to submit the data submission data Letter of Notice. Staff agreed with Andy.

WAPA asked who has access to the modeling contact spreadsheet. Staff commented that all data submitters have access to the modeling contact. The updated modeling contact spreadsheet is scheduled to be posted on February 28, 2020.

Staff mentioned the modeling contact spreadsheet has been helpful for SPP planning efforts also including the tariff studies coordination. Jonathan Hayes mentioned that SPP submitted entity contact database for NERC to house for compliance contacts. Jonathan mentioned that this would create efficiency for the industry.

Moses provided the MDWG group with an update on outstanding questions that staff received about the Pass 2 models. Moses explained an edited MOD project ratings header caused the light load rating discrepancies in Pass 2. The group discussed if there was a way to pull the ratings header information to avoid the issue in future model builds. Moses mentioned Siemens PTI would remove the headers for projects in a future release. Moses mentioned the issue with the 2025 Shoulder peak model. Additionally, Moses mentioned a small set of projects of certain type and status not applied in Pass 2. Moses mentioned staff informed the affected parties of the issue and staff will apply the missing projects in the next pass. Moses mentioned some data submitters noticed issues with the 25SH case. Moss mentioned that staff inadvertently did not apply a large set of MOD updates to this one particular case. Moses mentioned since the 25SH case does not have deliverables or requirements for the planning process outside of MMWG, staff can accommodate additional time to clean up this particular case if necessary.
AGENDA ITEM 5B – SHORT CIRCUIT

Michael Odom provided the update for the 2020 series MDWG short circuit model build. Michael mentioned that staff recently received updates from Mid-American Electric for their short circuit data, which was requested by November 15, 2019. Michael mentioned staff would work with the consultant to incorporate the update. Michael mentioned the project is still on schedule for a February 28, 2020 posting pending any unforeseen issues with the models.

AGENDA ITEM 5C – DYNAMICS

Shahrokh Akhlaghi provided a quick update for the 2020 series MDWG dynamic models that just kicked off in January 2020. Shahrokh mentioned the initial data update deadline is February 21, 2020. The group did not have any questions.

AGENDA ITEM 6 – MDWG MANUAL LANGUAGE APPROVAL (APPROVAL ITEM*)

Michael Odom gave the group an update on the manual language revisions. The group reviewed changes to the generator retirement language. The group discussed how to handle mothballed units. The group reviewed the redline language for retirements. The group discussed risk of dispatching retirement units in the SPP planning processes including ITP. Staff commented that for processes such as AQ and ITP, if the unit has firm service, the units can be called upon if the Pmax and Pmin values are stated.

The group then reviewed the language about station service and aux load: Aux load should be modeled per the state of the generator. The group discussed a scenario in which the unit is online, the aux load is off, and how the modeling for those elements should be conducted. The group leaned on the language that included should instead of shall to allow for the unique modeling situations like the one that was discussed. A member commented on how their hydro loads are set with the net load of 0 regardless of the generator status. The group discussed the possibility of a 10MWG cutoff for aux load. Some members in the group mentioned that TWG might be having similar discussions. The group discussed how the aux loads are handled in the ITP models. Staff mentioned the ITP Base Reliability aux loads are set through MOD similar to the MDWG models. Evergy commented that they model both a variable and fixed aux load amounts for all their owned units.

Action Item: Moses to include language about aux load in the ITP models in the posting email.

The group reviewed the relay section of the manual language changes. Michael Odom mentioned the relay section language was reviewed by the MDWG Dynamic Focus Group and then the Manual Task Force. The group discussed the need for standardizing the models instance number (MINs). Jason Shook asked if the language is requesting additional models to be provided then what is typically already provided. Sunny Raheem commented that he would expect the voltage and frequency relay models to be provided to show the actual response of
the units. Some members of the group agreed the language might be requesting more models than what is currently provided. The group agreed to have the manual task force to discuss the relay language further.

Nate asked the group how they would like to proceed with the approvals. The group suggested they would like to break out the approvals into manual language sections.

**Motion:** Reené Miranda moves to approve the manual language for “The capability amounts for PMAX, PMIN, QMAX, QMIN should not be changed until the unit is fully decommissioned”. Scott Schichtl second. The motion passed unanimously.

Material: FEB13_Attach3 - 6. SPP Model Development Procedure Manual 2020 v4.0 Feb 2020_Pending_Updated.docx

AGENDA ITEM 7 – BREAK

The group took a 10-minute break.

AGENDA ITEM 8 – 2021 ITP GEN AND LOAD UPDATE

Brooke Keene provided the MDWG group an update on the 2021 ITP generator and load efforts. SPS asked if updates based on member feedback received for the 2020 MPMs will be used in the 2021 load and gen review. Brooke mentioned typically the ABB data is utilized. However, SPP staff will discuss whether to incorporate the feedback.

AGENDA ITEM 9 – NERC TPL-001-5 STANDARD UPDATE

Jonathan Hayes gave an update on TPL-001-5. Jonathan mentioned there will be changes to spare equipment strategy, outages included in the models, etc. Jonathan mentioned TPLTF is been putting together a document for the rationale of selecting outages for inclusion in TPL assessments and will bring it to the MDWG for review. Jonathan encouraged entities to participate in TPLTF and provide feedback on the rationale. Chris Colson clarified that the inclusion of known outages removed from requirement 1 to requirement 2 of TPL-001-5 and the outages are no longer directly tied to duration.

Jeremy Harris asked since TPL has traditionally been run on peak cases, do the changes in TPL-005-1 open up the TPL assessment for other seasonal cases. Chris Colson responded that TPL-001-5 will probably become effective 6/1/2025, become effective 01 July 2023 and by transferring the outages under R2, the base models should be built using the requirements in the model build manual and then entities will have the flexibility to select outages in their TPL assessments for inclusion in the study.
enforceable on 01 July 2025. Requirement R2, Part 2.7 planned System shall continue to meet the performance requirements in Table 1 waived for P5/P8 events until 01 July 2029.

AGENDA ITEM 10 – 2019 SERIES MOD-033-1 VALIDATION SCOPE INTRODUCTION

Agenda item tabled for a future MDWG meeting.

AGENDA ITEM 11 – WORKSHOP AGENDA ITEMS REVIEW

Nate Morris reminded the group to take part in the Doodle Poll that staff sent out for the workshop meeting dates. Sunny Raheem outline the current list of workshop topics that staff has created. Sunny mentioned that staff would welcome any additional questions for topics from members. Holli Krizek asked if the workshop has the same focus as last year’s workshop. Sunny mentioned that based on the workshop survey, this year’s workshop would focus more on hands-on demonstrations of MOD, EDST, and how to submit data.

AGENDA ITEM 12 – SUMMARY OF ACTION ITEMS

1. Moses to include language about aux load in the ITP models in the posting email.

AGENDA ITEM 13 – DISCUSSION OF FUTURE MEETINGS

Nate Morris outlined the future MDWG, MDWG workshop, MDWG focus groups, and MDWG manual task force meetings

AGENDA ITEM 14 – ADJOURN (APPROVAL ITEM)

Nate Morris asked the group if they had any other topics for discussion before the group adjourned. The group did not voice any additional topics.

Motion: Jason Shook motioned to adjourn the meeting. Andy Berg seconded the motion. The group did not voice concerns during the discussion of the motion. The motion passed unanimously.

The meeting adjourned at 12:05 pm (CST).

Respectfully Submitted,

Sunny Raheem

Secretary
Attachments

FEB13_Attach1 - 1e. MDWG Meeting Agenda 20200213.docx

FEB13_Attach2 - 1f. Previous January 22, 2020 Meeting Minutes.pdf

FEB13_Attach3 - 6. SPP Model Development Procedure Manual 2020 v4.0 Feb 2020_Pending_Updated.docx
# REVISION HISTORY

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SECTION 1: INTRODUCTION

Purpose
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, Data Owners, equipment, and Data Submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, [www.spp.org](http://www.spp.org). Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, [www.spp.org](http://www.spp.org). The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

Scope of Applicability
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for Power System Modeling and Analysis Reliability Standard (MOD-032-1) and the provisions of the

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1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.
SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.
- Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

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\(^2\) Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

\(^3\) For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

**Applicable Data Submitters**

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner’s modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

A completed Letter of Notice identifying responsibilities between a Data Owner and a Data Submitter is required to be submitted to SPP. This Letter of Notice is included in the appendix section.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner's data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
Good modeling practice includes coordination of data submissions to the SPP PC that impact other systems. Data Submitters shall submit data to SPP (PC) and to the Transmission Planner (TP) of the system to which they connect per MOD-032-1 Requirement R2—*with those* Data submissions that may impact another Data Owners’ system(s). Each system should be coordinated with all applicable Data Owners for any data submissions.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT. Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in service for the case conditions specified (e.g., month; year). Existing or planned equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the Bulk Electric System (BES).
2. All non-BES equipment 60 kV and above, subject to the SPP OATT.
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT.
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT, excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT.
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.

5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Sixth Revised Volume No.1, Attachment AI, Part II-1.
8 Sixth Revised Volume No.1, Attachment AI, Part II-2.
9 Sixth Revised Volume No.1, Part III-30.
10 Sixth Revised Volume No.1, Part III-31.
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and Data Submitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes.** In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

Confidentiality and Proprietorship
The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG Case Type Set
The current MDWG Case Type Set can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

Steady-State and Short Circuit Data Format
PSS®E and MOD Users
The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users
For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

Typical Annual Models

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>2 Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>3 Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>4 Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>5 Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>6 Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>7 Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>8 Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years six through ten) transmission planning models. The SPP models are defined in the Annual Models.
table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models (case types) can be found on the SPP corporate website, www.spp.org.

Data Transmittal
Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. Electronic --- GlobalScape

2. E-MAIL --- SPPEngineeringModeling@spp.org

The preferred method of submittal is through the “SPP MDWG File Sharing Site”, GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

SPP Model Release Guidelines
Steady-State and Short Circuit Models
SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.

SPP Model Contact:
Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG Deliverables
Regional Coordinators
The Regional Coordinators will provide the following to the MMWG Coordinator(s).

1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.

2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG Coordinator(s)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.

1. Steady-State Cases
   Initialized steady state and regional contingency cases.
   a. Steady-State RAWD case file
   b. Conversion IDEV files

2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case


4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.

MDWG Contact List
The MDWG Contact List can be found on SPP’s GlobalScape under Modeling (CEII, RSD) → SPP Modeling Contacts → 3. Final Modeling Contacts

**NOTE** – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

**Compliance**

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

Engineering Data Submission Tool

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. **Transactions** – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. **Generators** – Required generator data that is not otherwise captured in the models including but not limited to the generator type, long name, and associated Auxiliary load.
3. **SPP Modeling Assignments** – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. **Load Details** – Identify loads not served by native model areas.
5. **Bus Details** – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. **Interregional Ties** – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. **Outages** – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts that meet TPL-001 requirements shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
### Table 1: Season Date Range and Cutoff Dates

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

### Load Forecast

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be not Coincident to the SPP region, meaning that the hour that a Data Submitter's system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter's load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such
location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have an updated service agreement, or are in the process of finalizing a service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS@E idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter's load forecast data comprisal:

1. Not Coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

**On-Peak/Off-Peak Models**

Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority Coincident Peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1&lt;sup&gt;st&lt;/sup&gt; through May 31&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1&lt;sup&gt;st&lt;/sup&gt; through September 30&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1&lt;sup&gt;st&lt;/sup&gt; through November 30&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1&lt;sup&gt;st&lt;/sup&gt; through March 31&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1&lt;sup&gt;st&lt;/sup&gt; through May 31&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1&lt;sup&gt;st&lt;/sup&gt; through September 30&lt;sup&gt;th&lt;/sup&gt; Typically 70% - 80% of Summer On-Peak load level</td>
</tr>
</tbody>
</table>

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.
Load Data
Load data is maintained in MOD via a profile file which is applied to the model. Profiles, Loads can belong to an Area that is not the same as the Bus Area. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID “R1”). These loads should be maintained in the Load Mapping worksheet of the EDST.

Area Summary Report
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity’s area slack machine shall be modeled within the entity’s model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.

12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**Tie Line Coordination**
Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member **must** coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**Line and Transformer Data**
Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The "from bus," “to bus”, and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code. The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.
3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified rate A (normal, continuous) and rate B (emergency) entered in the first two fields (RATEA and RATEB, respectively) for each seasonal model; use of the third rating field (RATEC) is optional.

6. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

7. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

**Bus Data**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range. For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:

1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).
NOTE: When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

<table>
<thead>
<tr>
<th>Voltage Range</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Below 69 kV</td>
<td>1</td>
</tr>
<tr>
<td>69 kV - 115 kV</td>
<td>2</td>
</tr>
<tr>
<td>115 - 138 kV</td>
<td>3</td>
</tr>
<tr>
<td>345 kV - 500 kV</td>
<td>7</td>
</tr>
<tr>
<td>500 kV - 765 kV</td>
<td>8</td>
</tr>
<tr>
<td>765 kV or above</td>
<td>9</td>
</tr>
</tbody>
</table>

1. For generator regulated buses, a desired voltage set point will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the Station Service or Auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.
**SHUNT DATA**

Shunt reactive devices are key components used, in conjunction with generating unit excitation, to regulate transmission system voltage, as well as facilitate operating flexibility while assisting to maximize transmission capacity. Shunt reactive devices are typically characterized as either static or dynamic, based upon their responsiveness to system voltage variations.

Static reactive devices tend to respond more slowly, either through automatic or manual switching according to a broader voltage schedule or range of system voltage conditions. Dynamic reactive devices tend to respond very quickly, automatically adjusting their reactive contributions to the system so as to maintain a voltage set point (Regulating device). The four primary static and dynamic reactive device categories are:

- **Fixed shunt device (Locally-switchable static devices)** - Typically require a switchman to physically close a switch in the field under de-energized conditions. These devices require human interaction at the location of the device in order to change the status and are not self-switching. These devices should be represented as fixed shunt devices in software simulations.

- **Switched Shunt, Locked mode (Remotely-switchable static devices)** – Can be placed in, or taken out of, service by a System Operator remotely operating a switch from a Control Center. These devices require human interaction in order to change the status, are not self-switching, are not used for automatic system adjustments, but are used for manual system adjustments (regulating device). These devices should be represented as switched shunt devices in locked mode (0) in software simulations and set to their expected seasonal Mvar (Binit) values.

- **Switched Shunt, Discrete mode (Automatically-switchable static devices)** – Can be placed in, or taken out of, service by an automatic controller (e.g., the Protection System) that actuate powered switch closure. These devices are self-switching, are used for automatic system adjustments (regulating device), but not used for manual system adjustments. These devices should be represented as switched shunt devices in a discrete switching mode (1, 3, 4, 5, or 6) in software simulations.

- **Switched Shunt, Continuous mode (Automatically-switchable dynamic devices)** – Reactive contribution is adjusted by an automatic controller. These devices are used for automatic system adjustments (regulating device), but not used for manual system adjustments. Examples of dynamic reactive devices include: static VAR compensators (SVC), static compensators (STATCOM), and direct current voltage source converters (VSC). These devices should be represented as switched shunt devices in a continuous switching mode (2) in software simulations.

Load flow software offers multiple options for modeling shunt reactive devices and care must be used when selecting the appropriate representation. The primary modeling capability considerations for non-rotating mass reactive devices are:
• Shunt implementation: fixed, or switched.
• Simulated control mode: Locked, discrete, or continuous.
• Regulated voltage band limits: high ($V_{hi}$) and low ($V_{lo}$).

Upon selecting the appropriate modeling representation for the non-rotating mass shunt reactive device, the Data Owners/Data Submitter shall ensure that the following is entered for:

**Non-regulating shunt capacitor or reactor device (static, locally-switchable device)**

• Fixed shunt (no control mode) with a unique shunt ID.
• Total reactive device admittance\(^\text{11}\) (MW and MVAR) that represents the aggregated contribution of the reactive banks or blocks installed as a fixed device.
• In-service status, set to zero (0) if the device is not in-service.

**Regulating shunt devices**

• Switched shunt with 'SW' shunt ID (forced by software).
• Total reactive device admittance\(^\text{12}\) (MVAR only), differentiated into quantities of admittance that represent the installed controllable device reactive banks or blocks, as appropriate.
• Regulated voltage band limits, either as a schedule ($V_{hi} \neq V_{lo}$) for static reactive devices or as a set point ($V_{hi} = V_{lo}$) for dynamic reactive devices, appropriate to the equipment.
• Reactive limits, for dynamic reactive devices only.
• Control mode-of-operation, as listed above:
  o Static, remotely-switchable device – locked, control mode (0).
  o Static, automatically-switchable device - unlocked, discrete control modes (1, 3, 4, 5, or 6).
  o Dynamic device – unlocked, continuous control mode (2).
• Assignment of the regulated bus, for switched shunt representations only.
• In-service status, set to zero (0) if the device is not in-service.

The Data Owners/Data Submitter should consider the load flow numerical solution stability implications of the regulated voltage band limits ($V_{hi}$, $V_{lo}$) when entering data for the shunt reactive devices. The ability of the load flow numerical solver to derive an acceptable voltage state may be impeded by a switched shunt with a discrete control mode whose reactive contribution, when switched, pushes the voltage of its connected bus outside of convergence tolerances. Therefore, a limit difference of less than 0.025 pu shall not be used when entering the regulated voltage band limits ($V_{hi}$, $V_{lo}$) for a switched shunt reactive device. Similarly, switched shunts shall not be connected to generator buses or to a generator bus through a zero-impedance branch.

All shunt reactive devices attached at transmission-level buses (i.e., 60 kV or greater) or attached to the tertiary of a transmission-level power transformer shall be modeled explicitly and not as loads or aggregated with loads. Further, static reactive devices connected to transmission lines are known as line shunts. The PSS®E load flow software allows line shunts to be modeled as part of the BRANCH

\(^{11}\) Shunt conductance and susceptance quantities are entered in units of MW and MVAR representing the total per-unit admittance at rated voltage, on system base MVA.

\(^{12}\) Shunt susceptance quantities (conductance is assumed to be zero) are entered in units of MVAR representing the total per-unit admittance at rated voltage, on system base MVA.
data record. An alternative approach is to model the line shunt explicitly by using an intermediate bus and zero-impedance branch (ZBR), as shown in Figure 1, even when the line shunt is locally-switchable only and expected to match the in-service status of the connected branch. In this scenario, losing the transmission line, but not the line shunt, can cause low voltage conditions that may not be realistic.

Figure 1. Example depiction of line reactor modeling.

The Data Owner/Data Submitter must remember that the switched shunt reactive device control mode employed by the load flow software offers significantly more flexibility than shunt reactive devices implemented in the transmission system. Care should be taken to best represent the actual operation of installed shunt reactive devices and not allow unlocked control modes when inappropriate. During the model build process, similar to the process of case conditioning prior to analysis, remotely-switchable devices may be unlocked and automatically-switchable devices may be locked, expressly for the purpose of obtaining a converged load flow solution. However, care must be taken to ensure that the final state of the model contains the correct control mode, including locking, appropriate to the shunt reactive devices represented. The Data Owners/Data Submitters should also consider individual device protection settings as they relate to voltage.
control mode and limits.

**Generator Data**

Generating unit MW and MVAR output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits with consideration of MOD-025-2 and SPP Planning Criteria 7.1.1., or company-specific procedure for testing the gross capability of the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with Auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities.

For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to XSOURCE Table.

For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour.

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance information is provided.

When modeling mothballed and future retired units, the unit will be modeled offline (in-service status = 0). The capability amounts for PMAX, PMIN, QMAX, and QMIN should not be changed until the unit is fully decommissioned) similar to units that are not dispatched in the particular seasonal model. Unit retirement information will be provided in a separate document and posted through a secure website. Decommissioned units should be removed from the models.

**Modeling Process for Generator Parameters**

a. The Generator parameter P_{MAX} shall be modeled as a gross seasonal maximum capability based on SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.
b. Generating plant Station Service load and Auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All Station Service load and Auxiliary load representations shall:
   
   i. Be modeled explicitly on the appropriate bus, corresponding to the voltage to which the Auxiliary load is served. Model representations of Auxiliary load connected to the generating unit bus (Figure VII-1), Auxiliary load modeled with separate transformation (Figure VII-2), and Auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   
   ii. Be annotated as non-scalable.

   ![Figure VII-1. Common bus representation](image1)
   ![Figure VII-2. Separate transformation representation](image2)
   ![Figure VII-3. Transformer high-side representation](image3)

   c. Experience has shown that generating plant Station Service load and Auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant Station Service load and Auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable Station Service load and Auxiliary load.

   If generating plant Station Service load and Auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant Station Service load and Auxiliary load shall use “Sn” in the Load ID for one or more aggregated generating plant Station Service loads (Figure VII-4a).

   If generating plant Station Service load and Auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant Station Service load and Auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b).

   13 Station Service load and Auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant Auxiliary load.
The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “Fn” in the Load ID field to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “Vn” in the Load ID field to designate variable load quantities that do vary with plant dispatch.

Figure VII-4. Examples of generating plant Auxiliary load representations (aggregated, combined, and discrete).

Only generating plant Station Service load or Auxiliary load IDs should be labeled with “Sn”, “Fn”, or “Vn”; all other load types should be labeled differently.

Station Service or Auxiliary load modeling should be done in accordance with the state of the generator as follows:

<table>
<thead>
<tr>
<th>Generator State</th>
<th>Aggregated “Sn” SS or Aux Load</th>
<th>Variable “Vn” SS or Aux Load</th>
<th>Fixed “Fn” SS or Aux Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>In-Service</td>
<td>In-Service</td>
<td>In-Service</td>
</tr>
<tr>
<td>Offline</td>
<td>In-Service</td>
<td>Offline</td>
<td>In-Service</td>
</tr>
<tr>
<td>Decommissioned</td>
<td>Removed from model</td>
<td>Removed from model</td>
<td>Removed from model</td>
</tr>
</tbody>
</table>

Aggregated Station Service or Auxiliary loads shall be updated to reflect the dispatch of the associated generator.

Modeling of Wind/Solar Renewable Resources P_{GEN}

- Spring Light Load Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP minimum load hour corresponding to the season of the Light Load case, not to exceed each facility's firm service amount. The methodology used to calculate replacement data is described in the ITP Manual. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

14 “n” represents a unique numeric value. PSS®E requires each load placed at a bus to have a unique Load ID.
• On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the case(s) at each facility's latest five-year average (or replacement data if unavailable) for the applicable seasonal SPP coincident\textsuperscript{15} peak, not to exceed each facility's firm service amount.

• SPP will make available the initial dispatch of renewable resources with long-term firm transmission service based on historical seasonal five-year average with the initial model pass of the each SPP MDWG model build. Any renewable resource modeling data submitted to the PC, after the initial dispatch list is provided, will be dispatched at the seasonal state dispatch percentage of the renewable resource's nameplate amount.

• When an affected party disagrees with the dispatch amount for a facility, the affected parties involved should coordinate to update the dispatch amount. If agreement cannot be reached, the case can be brought to the MDWG for a decision.

• Responsibility for validating and providing renewable resource dispatch updates falls to the affected parties.

• For resources that do not have firm service, $P_{\text{gen}}$ values should not exceed average historical seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak, Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net capability of a resource determined according to SPP Planning Criteria section 7.1.5.3 should be followed.

**Shortfall Guidance Process**

Under no circumstances in the Near-Term Transmission Planning Horizon shall generating resources be dispatched in excess of the firm transmission rights allotted to that resource. In the Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm transactions from neighboring modeling areas are insufficient to serve customer load, the following should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All parties are required to add their respective coordinated reciprocal record(s) to the transaction worksheet of the EDST.

2. Future generation resources that have progressed, at minimum, to the Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the Generation Interconnection (GI) queue, may be modeled (in the Long-Term Transmission Planning Horizon models only) following these requirements:
   a. The in-service date shall be based on the expected in-service date of the GI study.
   b. In order to identify future GI queued generation, the unit name shall be the GI gen number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID designation appropriate in PSS®E).
   c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.

3. Future Exploratory Generation resources may be modeled in the Long-Term Transmission Planning Horizon models following these constraints:
   a. In order to identify future Exploratory Generation, the unit ID of Zx (where x is any second ID designation appropriate in PSS®E) shall be used.
   b. When available, Exploratory Generation should be based upon the host TO Resource Plan.

\textsuperscript{15} SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
d. The addition of Exploratory Generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

EXTERNAL RESOURCE MODELING

Purpose
This procedure assures that members adhere to a uniform process when modeling external resources in SPP.

Modeling Process
If a member acquires external resources outside their Model Area, the following modeling process should be followed:
1. All buses should be assigned numbers that are in the host’s Model Area bus number range.
2. Area Number/Name should be the host’s Model Area number.
3. Zone Number/Name should be in the host’s Model Area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

Owner Data and Line Mileage Data (SSAE Control)

To meet the Statement on Standards for Attestation Engagement (SSAE) requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore; it is important that Members keep the data current in MOD.

The MMWG Procedure Manual contains information related to the following:
1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

Initial Run Review

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. Area Interchange
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions
between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**
Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are
used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**
   This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**
   All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

   The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST.
   The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

   The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:
   i. \( QT \rightarrow \text{MAX} = \text{one-half of MW rating} \)
   ii. \( QB \rightarrow \text{MIN} = \text{negative one-third of MW rating} \)

   If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The
desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
**Periodic Model Updates**

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

**System Impact Studies/Expansion Options Studies (Long-Term)**

SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

**MDWG Updates**

At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:

1. Using the steady-state update procedure to update MOD.
2. Submitting a PTI, IDEV format file to perform the RDCH operation. **This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.**

   **It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.**

The most current update to the models will always be posted on the SPP file sharing site.

**Program Operation**

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

**PTI-PSS®E Data Format**

Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a **comma** (not blanks). Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is **added** to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The **modification** of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data...
for that bus will be removed (e.g., branches, transformers, generators, and loads). **The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified.** Data currently in the model is used as the default value for data fields not specified in the format.

**Steady-State Solution**

The steady-state solution will have “Area interchange control” with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

**Error Screening**

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
6. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of Rate A) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

**STEADY-STATE MODELING REQUIREMENTS**

**GENERATORS**

1. All steady-state generators, including synchronous condensers and Static VAR Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-
state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the XSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS FOR XSOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous:</td>
<td>Unsaturated sub-transient reactance (X''_d) [PU]</td>
</tr>
<tr>
<td>Detailed</td>
<td>Subtransient</td>
</tr>
<tr>
<td>Synchronous:</td>
<td>Unsaturated transient reactance (X'_d) [PU]</td>
</tr>
<tr>
<td>Non-Detailed</td>
<td></td>
</tr>
<tr>
<td>Classical or</td>
<td></td>
</tr>
<tr>
<td>Transient</td>
<td></td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated transient reactance (X'_d) of single machine [PU*]</td>
</tr>
<tr>
<td>Wind Type 1</td>
<td>OR</td>
</tr>
<tr>
<td>Wind Type 2</td>
<td>Locked rotor reactance (sum of rotor and stator leakage reactances) [PU]</td>
</tr>
<tr>
<td>Renewable:</td>
<td>Unsaturated transient reactance (X'_d) of single machine [PU]</td>
</tr>
<tr>
<td>Wind Type 3</td>
<td></td>
</tr>
<tr>
<td>Renewable:</td>
<td></td>
</tr>
<tr>
<td>Inverter-Based</td>
<td></td>
</tr>
<tr>
<td>Solar PV</td>
<td></td>
</tr>
<tr>
<td>Wind Type 4</td>
<td></td>
</tr>
<tr>
<td>Renewable:</td>
<td></td>
</tr>
<tr>
<td>Wind Type 5</td>
<td>Unsaturated sub-transient reactance (X''_d) [PU]</td>
</tr>
</tbody>
</table>

* PU values should be based on the rated terminal voltage and machine MVA base

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation. If a user model representing particular SVC
and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:
   a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used
   b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation
   c. Different development phases
      i. These representations should be combined as the phases are placed in service as applicable

OTHER DEVICES

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV.
   Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.

   If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using $R=0.00000 + X=0.0001$ and $B=0.00000$. These values facilitate differentiating
between bus ties and other low impedance lines, utilizing the zero impedance threshold THRSHZ in the PSS®E program. When connected between two voltage controlled (generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines should be modeled using an impedance of R=0.0001 + X=0.002 and B=0.00000. This allows use of near-zero impedance attached to controlled buses that will be large enough to avoid significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do not represent real devices. Their use in representing three winding transformers is obsolete. Negative branch reactances limit the selection of steady-state solution techniques and should be avoided.

8. Transformers – To adequately model transformers, the following parameters, at a minimum, are required:

   a. Nominal voltage of windings and bus reference to which the appropriate winding is connected

      When entering transformer data, the rated voltage for all applicable windings should be specified. For non-LTC transformers, the winding voltage should be set to the tap voltage.

      A recommended approach is to model three-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 1
      - X, or Low-Voltage, Winding = Winding 2
      - Y, or Tertiary-Voltage, Winding = Winding 3

      A recommended approach is to model two-winding transformers such that the winding buses map to the transformer windings as follows:
      - H, or High-Voltage, Winding = Winding 2
      - X, or Low-Voltage, Winding = Winding 1

      The two-winding transformer winding map is in this order by default since PSS®E requires all two-winding transformers with Load Tap Changers (LTCs) to specify the tap bus as Winding 1. While not all LTC transformers have the tap on the X winding, this is common with most transformers.

   b. Impedance(s)

      A recommended approach to modeling transformer impedance is to set the winding MVA base to the system MVA base which is 100 MVA, entered as positive sequence data in pairwise (delta) format. Care should be taken to when entering transformer impedance data to ensure that the data entered corresponds to the appropriate base (system or winding).

      Enter zero sequence data in the format appropriate to the connection code.

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16 Care should be taken to enter the rated voltage, which may be different than the nominal voltage of the system for all transformer windings. There can be a difference between the rated voltage of the system and the transformer (nominal).

17 Two winding representation in PSS®E allows the user to select which bus number (from or to) the winding resides.
Connection codes <10:
- The zero sequence data must be entered as T-model format

Connection codes >10:
- The zero sequence data must be entered in pairwise (delta) format

c. Tap ratios
Depending on the PSS®E winding code used for the transformer, the setting should be either p.u. or kV. It should be noted, “tap ratio”, “winding ratio”, and “turns ratio” are synonymous.
- For transformers with no taps, use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
- For transformers with automatically adjusting, under-load tap changers (ULTC), it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
  - For parallel transformers, it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio for both transformers in order to prevent circulating VARs.
- For transformers with non-automatically adjusting, under-load tap changers (ULTC), it is recommended to use the tap ratio as set in the field.
- For transformers with no-load tap changers (NLTC), it is recommended to use the tap ratio as set in the field.
- It is recommended that Delta-Wye phase angle differences are incorporated appropriately in the models.

d. Minimum and maximum tap position limits
- Minimum and maximum tap position limits (RMIN and RMAX) shall be modeled based on transformer test report or manufacturer nameplate data.

e. Number of tap positions (for both the ULTC and NLTC)
- Under-load tap changers (ULTC) control bus, total number of tap positions, and tap setting shall be specified.
- No-load tap changers (NLTC) total number of tap positions and the tap setting shall be specified.
- Transformer tap positions are discrete. The total number of transformer tap positions is a fixed quantity and shall be entered. The maximum and minimum transformer tap positions represent the physical boundaries of the transformer’s capability to modify its winding impedance to achieve a control objective. Transformer tap changing control modes may include voltage regulation, as well as real and reactive power control. Automatically-adjusting under-load tap changing transformers (ULTC) shall specify a control mode, the bus that is being controlled, and the control limits defined by the maximum and minimum transformer tap positions.

18 It is noted that PSS®E provides transformer tap changer limit fields called VMAX and VMIN, regardless of control mode. For example, if a real power control mode is selected, the user must enter MW quantities in the VMAX and VMIN fields.
• For transformers with untapped windings, the number of tap positions shall be “99” to indicate that there are no taps. PSS®E does not allow a value of “1” to be used as a tap position.

f. Regulated bus (for voltage regulating transformers)
   • The regulated bus is the location where the transformer is regulating voltage. Typically this regulated bus is connected to a transformer winding bus.
   • A limit difference of less than 0.0125 p.u. shall not be used when entering the regulated voltage band limits (VMAX, VMIN) for an automatically adjusting, under-load tap changers (ULTC) transformer.
   • It is recommended that the voltage band limits VMAX and VMIN be no less than 0.025 p.u., to prevent toggling of the ULTC during simulation iterations.

g. In-service status
   • In-service status, set to zero (0) if the device is not in-service.

h. Vector group and Connection code
   • The vector group shall match the topological configuration of the buses representing where the windings are connected (e.g. A 115/69 kV load serving transformer with a vector group of Dyn11 must show the winding 1 bus [Delta winding] as the 115 kV bus).
   • Transformer connection codes and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.
   • The transformer core construction should be considered (shell type or core type)

i. Transformers Controlling Reactive Power Flow
   • The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.


20 Reference the TPL-007-1 Data Collection Template User Guide document under the Transformers section/Core Type. https://www.spp.org/spp-documents-filings/?id=197519
9. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes.

PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:

a. Real-time operational auto or manual adjustment operation of the PST.

b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.

c. Real-time operational MW flow limits (e.g. ±20 MW).

d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).

e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.

f. Applicable long-term firm transmission service levels for the PST.

11. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

12. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

13. Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

14. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

15. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output
capabilities should be given unless the generator terminal bus is explicitly modeled, the
generator step up transformer is modeled as a branch, and unit load is modeled at the bus
or buses from which it is supplied.

16. Small Generators, Capacitors, and Static VAR Devices – Small generators (e.g., 10 MVA),
small capacitors, and small SVCs have limited reactive capability and cannot effectively
regulate transmission bus voltage. Modeling them as regulating increases solution time.
Consideration should be given to modeling them as non-regulating by specifying equal
values for QMIN and QMAX. If several similar machines or devices are located at a bus and
there is a need to regulate with these units, they should be lumped into an equivalent to
speed solution.

17. Coordination of Regulating Devices – Multiple regulating devices (generators, switched
shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple
buses connected by Zero Impedance Lines as described above, should have their scheduled
voltage and voltage control ranges coordinated.
Also, regulated bus voltage schedules should be coordinated with the schedules of
adjacent buses. Coordination is inadequate if solving the same model with and
without enforcing machine regulating limits causes offsetting MVAR output changes
greater than 500 MVAR at machines connected no more than two buses away.

18. Over and Under Voltage Regulation – Regulation of voltage schedules exceeding 1.10 per
unit, or below 0.90 per unit should be avoided.

19. Flowgates – All transmission elements comprising part of one or more flowgates should be
included in the data submitted by each region. A flowgate is a selected transmission
element or group of elements acting as proxy for the transmission network representing
potential thermal, voltage stability, rotor angle stability, and contractual system constraints
to power transfer.

20. Fixed Shunts – All fixed shunt elements at buses modeled in the steady-state should be
modeled explicitly (not as loads or included with load). The status should be set to zero if
the shunt is not in service. Fixed shunt elements that are directly connected to a bus should
be represented as bus shunts. Fixed shunt elements that are directly connected to and
switch with a branch should be represented as line shunts.

21. Switched Shunts – Switched shunt elements at buses modeled in the steady-state should be
modeled explicitly. Continuous mode modeling using a switched shunt should not be used
unless it represents actual equipment (e.g. SVC or induction regulator). The number and
size of switched admittance blocks should represent field conditions. The bandwidth
(difference between VSWHI and VSWLO) of switched shunt devices should be wide enough
that switching one block of admittance does not move the voltage at the bus completely
through the bandwidth, thus causing solution problems at the bus. It is recommended that
the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage.
Switched shunts should not regulate voltage at a generator bus, nor should they be
connected to the network with a zero impedance tie.

22. Static Var Systems – Static var elements should be modeled with accurate reactive power
(leading/lagging) limits. An accurate voltage set point, as well as any associated
fixed/switched shunt equipment should also be modeled based on actual seasonal
operation. Out-of-service Static Var Systems should be modeled with an in-service status
equal to zero. In-service Static Var Systems should be modeled with an in-service status
equal to one.

23. DC Transmission systems – DC transmission systems must be represented with a
sufficiently detailed model to simulate its expected behavior.

24. Interchange Tolerances – In a solved case, the actual interchange for any area containing a
Type 3 (swing) bus should be within 25 MW of the specified desired interchange value.
(Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

25. Scheduled Interchange vs. Scheduled Tie Line Flows – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

Causes of Non-convergence and Problems in Merged Base Case Models

Causes of Non-convergence
1. A line whose impedance is very small as compared to that of a line connected in series with it.
   (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)
2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.
3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during Equivalencing.
4. A system’s regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.
5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.
6. Unrealistic tap changing transformer tap limits.
7. Radial system is very large.
8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.
10. Not solvable from flat start.
11. Fictitious regulation of buses.
12. Extremely low voltage schedules.
13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.
14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.
15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
**Troubleshooting**

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the “From” bus and the second-named bus is taken as the “To” bus. The “From” bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, \( \theta_A < \theta_B \).
   c. Assuming \( \theta_A \) and \( \theta_B \) stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the “From” bus or tapped bus is specified with positive real power limits.
   e. The “Controlled Bus” specified should be the same as the tapped bus to be consistent and avoid confusion.

**Note:** The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

**Balancing and Transactions**

A core principal of steady-state power flow modeling\(^{21}\) is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area\(^{22}\). While typically analogous to a

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\(^{21}\) The traditional power flow formulation is the matrix algebraic calculation of voltage phasor (magnitude and angle) at each interstitial connectivity node (bus) within an impedance network under balanced three-phase, steady-state conditions.

\(^{22}\) Model areas typically have a single generator designated as the area slack machine, although this is not a modeling constraint. The area slack machine is analogous to the system swing machine in that it compensates for the power imbalance within the model area, when the power flow solution is solved to respect inter-area transfers (area net interchange control).
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\textsuperscript{23} loads and induction machine loads to be assigned to model areas that may be different than the buses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

![Figure 1. Example of interconnected model areas.](image)

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\textsuperscript{23} ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (Pgen) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

Inter-area Bilateral transaction description

Data Owner A exports MW to Data Owner B
Data Owner B imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>Not SPP</td>
<td>2</td>
<td>Area 2</td>
<td>2</td>
<td>Data Owner B</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

Figure 3. Example of Inter-area transfer (transaction).
6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.

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**Figure 4. Example of Intra-area transfer (transaction).**

**Intra-area Bilateral transaction description**

Data Owner A exports MW to Data Owner C
Data Owner C imports MW from Data Owner A

**Transaction accounting in Data Submittal Workbook**

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>XYZ112</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>XYZ112</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

**Transaction Update**

The transaction workbook should be updated to show a transaction from the control area where external resource is located to the generation owner control area. If the external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area’s number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

- **No Transaction Needed**
  Source Area: XXX
  Sink Area: YYY
  Sink Load: XXX

- **Transaction Needed**
  Source Area: XXX
  Sink Area: YYY
  Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.

**SUBSTATION NODE-BREAKER MODELING**

Detailed substation node-breaker data is fully integrated into the PSS®E engine beginning with version 34. Substation node-breaker data is an extension to the bus-branch model, and is a container of nodes and switching devices. With the node-breaker data, there are a few data fields that represent the substation that must be uniquely specified within SPP, as well as the Eastern Interconnection; therefore, requirements must be set in place. For this section, the term substation also includes switching station.

Data Submitters shall submit node-breaker modeling information for any Extra High Voltage (EHV) substations within the SPP footprint in the approved format; node-breaker modeling information for non EHV substations may also be submitted.
SUBSTATION NUMBERING
The substation number should reflect the bus number of the highest voltage bus modeled at the station. By picking an existing bus number for the substation to represent the substation number, this ensures uniqueness in the model. The existing bus-branch model for a substation may be modeled with more than one bus for the same base kV, at which time a choice must be made. Preferably the bus number that has the most elements connecting to it should be used, and typically this is the lower bus number, however, it is up to the discretion of the Data Submitter to pick a bus number.

Example:
This one-line diagram shows that STATION A has only one 345kV bus, but since there is a reactor in that substation, MDWG might model another bus # 99902 for that reactor. This new bus # is only in PSSE and not in the one-line diagram or EMS model, thus the substation # should be 99900 and not 99902 since 99900 has the most elements connected to it.

SUBSTATION NAMING CONVENTION
The substation name should reflect the substation name with an SPP identifier and must be unique to the Eastern Interconnection. Substation names can have up to 40 characters, and the naming convention shall include a prefix of “SPP “, followed by the substation name as determined by the Data Submitter, up to 36 characters. Additionally, the substation names shall be limited to alphanumeric characters, hyphens, and underscores.

Example: Substation Name: “XXXXYYYY”
- XXXX represents an “SPP “ prefix (4 characters including underscore)
- YYYYY represents the specific station name determined by the company (up to 36 characters)
- Example: “SPP_TECUMSEH_HILL” or “SPP_WERE-TECUMSEH-HILL”

SUBSTATION PHYSICAL DATA
Additional physical information is retained as part of the node-breaker Substation network record. This information is used directly for geomagnetically-induced current calculations and indirectly for displaying relative bus locations on a single-line diagram. Geographic latitude and longitude shall be submitted in decimal degrees with at least three decimal precision (e.g., 45.001) for each substation that includes equipment operated at 200kV and above. Only positive decimal degree values between 25°N and 50°N latitude (e.g., 25.000 to 50.000) and longitudes to the west of the Prime Meridian between 85°W and 115°W (e.g., -85.000 to -115.000) are acceptable. Substation grounding resistances shall be submitted in Ohms with at least one decimal precision (e.g., 0.2 Ohms) or, in the rare instance when a substation is ungrounded, as ",-1”.

SUBSTATION NODES
Substation nodes create the mapping for the node-breaker model. Minimal information is required for these including Node Number, Node Name, and the Bus Number that they are represented within. Node numbers need to be unique to that substation.

SUBSTATION SWITCHING DEVICES
Substation switching devices need to be modeled in order to capture the full impacts of a detailed substation node-breaker model. A switching device name does not need to be unique to that
substation. There are a few different device options including a breaker, which acts as an interruptible device in the event of a fault, a switch, which is used to simulate a manual opening of a device, or a generic connector, which is used to represent bus work without an applicable switching device. Although higher levels of detail for a substation node-breaker model are not required to appropriately simulate contingency events, fault current interrupting devices shall be modeled. By modeling these devices, advanced contingency events can be automatically identified during analysis.

Example:

The diagram on the left is a one-line diagram with various switching devices whereas the diagram on the right shows the same topology translated into a node-breaker model in PSS®E.

Similar to branches, switching devices have sets of ratings. These ratings are optional, but if used, should represent Rate 1 (normal, continuous) and Rate 2 (emergency) entered in the first two fields (RATE1 and RATE2, respectively) for each seasonal model. Although higher levels of detail for a substation node-breaker model allow for ratings of terminal equipment and breakers to be modeled explicitly, the branch (line and transformer) model ratings should continue to consider this equipment as part of its rating. This is to allow for the bus-branch model to continue to have accurate ratings incorporated in the models if the substation node-breaker model is not used. Breaker interrupting capability ratings shall not be included as part of the ratings for switching devices.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPP reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the SPP RTO with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:
1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamic model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code

The schedule for submission of Dynamic data and list of MDWG Dynamic models (case types) can be found on the SPP corporate website, www.spp.org.

Dynamics Data Submittal Requirements and Guidelines
1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit.
   The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.
   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.
   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.
2. All synchronous generators and condensers shall also include representations of the generator, excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.

c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.

d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), Flexible AC Transmission System (FACTS), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

6. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

7. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented. Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

8. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

9. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

10. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-
governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

11. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

**Miscellaneous Other (MINS) Dynamic models**

1. If a generator, transformer, or capacitor has in-service relay protection that operates in 10 seconds or less, then the relay models shall be submitted when available. Inverter-based generator resources shall have frequency and voltage protective relay models.

2. PSS®E Model Instance (MINS) values for “Miscellaneous Other” models should be a unique eight digit number. The first six digits should be the bus number at which the model is being applied. The last two digits should be a unique number designating a particular application of a “Miscellaneous Other” model at the bus. Under no circumstance shall a unique eight digit MINS number be repeated.

   MINS example: 59999900 VTGDCAT  
   Bus number = 599999        
   Unique identifier = 00      
   Relay model = VTGDCAT

3. Unique MINS values are required for VTGDCAT/VTGTPAT, FRQDCAT/FRQTPAT, SAT2T, and SWCAPT relay models.

   PSS®E Miscellaneous Other (MINS) Dynamic model types:

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTGDCAT/VTGTPAT</td>
<td>Under/over voltage generator bus disconnection relay.</td>
</tr>
<tr>
<td></td>
<td>Under/over voltage generator trip relay.</td>
</tr>
<tr>
<td>FRQDCAT/FRQTPAT</td>
<td>Under/over frequency generator bus disconnection relay.</td>
</tr>
<tr>
<td></td>
<td>Under/over frequency generator trip relay.</td>
</tr>
<tr>
<td>SAT2T</td>
<td>Transformer saturation model.</td>
</tr>
<tr>
<td>SWCAPT</td>
<td>Switched capacitor bank model.</td>
</tr>
</tbody>
</table>

**PROCEDURE FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES**

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints
are satisfied, convergence within tolerance, even from a flat start, should not take more than
the default number of iterations. However, there is usually no reason to use a flat start if the
case being updated was solved.

b. Generator checks using a list of all data to spot unrealistic, typically default, generator data
values. [LIST, option 5] There is no checking activity listing only machines having suspect
values of the following

i. Machine MVA on the default base of 100. Although models will
work if all load flow and dynamic model parameters are entered
on this basis, limit checks will not work correctly.

ii. Source impedance of 1.0 p.u. on machine MVA base. This value is
substantially higher than normal for synchronous machines.

iii. Source impedances equal to or less than zero. These will cause
generator conversion to fail.

iv. Real and/or reactive power limits of +9999 or −9999.

c. Checks which report abnormal values

v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]

vi. Bus voltages below 0.95 p.u. except in the case of generator
terminal voltage buses connected to the transmission bus by a
step-up transformer with a tap ratio significantly off nominal.
[VCHK]

vii. Overloaded generators. [GEOL]. Note that this activity checks
machine output against the machine MVA base, MBASE, not
against PMAX, PMIN, QMAX, and QMIN.

viii. Branches with extreme impedances or tap ratios [BRCH].
Suggested options are:

a) Small impedance. Note that very small impedances can be treated as zero
impedance ties by selection of parameter THRSHZ and these will not be a
problem.

b) Negative reactance. These are typically found in Y representations of three
winding transformers. Solution activity SOLV may not be used on cases
containing such branches and MSLV may not be used if they are present at
a Type 2 or 3 (generator) bus.

c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are
normal on long EHV lines but others should be checked. Negative values
are occasionally used for magnetizing impedance on transformers but this
usage is not recognized in the PSS®E Program Operation Manual.

d) Parallel transformers. Minor tap ratio differences may simply reflect field
conditions, but differences exceeding one step should be checked to guard
against inadvertent errors.

e) High tap ratios.

f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage
return” for no change.

i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or
zones should be used cautiously if generators having default PMAX (+9999)
and PMIN (-9999) limits are present.
ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.
   a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]
   b. Read in the raw data file just created. [READ]
   c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]
   d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].
   e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)
   a. Specify CONEC, CONET, and COMPILE files.
   b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using “user dynamics”.
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE]
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.
ii. A tabulation of conditions at each online machine
   a) Terminal voltage
   b) Exciter output voltage
   c) Real and reactive power output
   d) Power factor
   e) Machine angle in degrees
   f) Direct and quadrature axis currents on machine base.

iii. A diagnosis of initial conditions, either
   a) “Initial conditions check OK”, or
   b) A listing of suspect initial conditions generally states whose time derivative is not “small” (relative to the value of the state). These may be caused by inconsistencies between the real and reactive power scheduled for a unit by the load flow (including automatic changes in reactive power to hold bus voltage at a target level) or by parameter errors.

iv. For models flagged in steps i) through iii), consider using activity [DOCU] to identify parameters which may be causing problems. This activity will also give the automatically calculated values of exciter model parameters, which are derived if the corresponding parameters, as read in, are 0. Other warnings may indicate errors in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence monitor [RUN,CM] can indicate where problems are, but considerably increases the amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field voltage and terminal voltage will be output for each exciter model and may be reviewed in tabular or graphical form. Satisfactory response is indicated if the terminal voltage settles to the specified value within a few seconds, if the field voltage is reasonable, and the response is free of
   a. Excessive overshoot
   b. Sustained oscillations
   c. High frequency noise (may be caused by using too long a simulation time step.)
   d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4 “non-continuous” regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical power and speed deviation will be output for each shaft where a governor model is present and may be reviewed in tabular or graphical form. Models of cross-compound unit governors specify two machines so four output variables are used. Steam or combustion turbine unit governors may require up to 20 seconds to attain equilibrium, and hydro units even longer, even if they are well tuned. Satisfactory response is indicated if speed deviation settles to approximately (- K) = (-1 / R), mechanical power to (1-1/K) times the specified value, and the response variables are free of excessive overshoot or sustained oscillations.
Dynamic Data Format

PSS®E Users

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyre file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

Non-PSS®E Users

Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

Acceptable Dynamic Model Information

The PSS®E simulation software dynamic machine models may be used as long as they are included on the NERC List of Acceptable Models for Interconnection-Wide Modeling and not identified as unacceptable models on that list. The NERC acceptable dynamic model list can be found on the NERC SAMS website ➔ SAMS Reference Materials ➔ NERC Acceptable Model List.

Significant improvements to models may occur over time and models may become obsolete, not recommended, or unacceptable models. Unacceptable models might still be available in the PSS®E software; however, those models must be replaced with more suitable current acceptable models.

User-written dynamic models will only be allowed under the following conditions:

1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes.
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment from the Data Owner to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified of request for conversion to an acceptable model by SPP or Transmission Planner.

MDWG developed a subset list of acceptable dynamic models based on the NERC acceptable dynamic model list and adheres to the guidance outlined in the MDWG Dynamic Models Guidelines document.

Dynamics Data Validation Requirements
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone satisfactory initialization and 20-second no-disturbance simulation checks for each dynamics case to be developed. The procedures outlined in Section III.H* of this manual (*yet to be written) may be applied for this purpose.

Guidelines
1. Dynamics data submittals containing typical data should include documentation which identifies those models containing typical data. The CON conservation models, such as GENROA and GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this purpose. When typical data is provided for existing devices, the additional documentation should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal, nuclear, combustion turbine, hydro, etc.).
2. The voltage dependency of loads should be represented as a mixture of constant impedance, constant current, and constant power components (referred to as the ZIP model). The Regions should provide parameters for representing loads via the PTI PSS®E CONL activity. These parameters may be specified by area, zone, or bus. Other types of load modeling should be provided to MMWG when it becomes evident that accurate representation of interregional dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator
Regional Coordinators have two options, described below, for submitting dynamics data to the MMWG Coordinator.

Dynamics Data Updates Using Excel Template
Regional dynamics data updates are incremental to the dynamics data in the previous year release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in SDDB are consistent with those in the MMWG steady-state to be made dynamics ready. The table below describes the various types of updates and the required data and information that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a dynamics model</td>
<td>Bus name, unit ID, model name, parameter name, new value</td>
<td>No</td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
</tbody>
</table>
Delete a model | Bus name, unit ID, model name | No | A stabilizer is removed.
---|---|---|---
Replace a model with another model of the same equipment group | Bus name, unit ID, model name for deleted model. | Yes for new model. | 1. A DC exciter is replaced by a static exciter. 2. A classical machine model is replaced by a detailed model.
Change bus name and/or unit ID for all models of an existing unit | Old and new names; old and new unit IDs | No | 
Change bus number | No | No | Maintain the same name and unit ID and the model data will follow automatically.
Add dynamic models for a new generating unit | Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type | Yes | Same requirements whether unit is at new or existing bus.
Remove a unit and all associated models | Bus name, unit ID | No | 

**Complete Set of Dynamics Data**
The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**
SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators the positive and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

Mutual Impedance

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line. Zero-sequence current is only present during ground faults, so the consideration of mutual coupling effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence current.
It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.\textsuperscript{24}

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSS®E, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSS®E models can be identified by checking when mutual impedance data is modeled and updated in a company’s primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

\textit{Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass \textit{N} or Final).} The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the MDWG Powerflow models. All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint. The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company's RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

All transformers shall have a Vector Group and corresponding Connection Code in PSS®E 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary

\textsuperscript{24} \textit{NERC Lesson Learned: Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements}
analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of the modeled sequence information prior to finalization.

Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.
SECTION 6: DEFINITIONS

These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner**\(^{25}\) – The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Data Submitter**\(^{1}\) – The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered is a power export and a negative value is considered a power import.

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\(^{25}\) Not a NERC functional entity
Model Area – The collection of model objects comprising an entity’s network and uniquely numbered in PSS®E.

Peak Demand – The highest demand including transmission losses for energy measured over a one clock hour period.26

PSS®E – Siemens PTI’s Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

PSS®E MOD – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

PSS®MOD File Builder – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS®MOD Modeling projects by comparing PSS®E models.

Transaction (Model) – A modeled purchase and/or sale of power.

Non-scalable load – Load that does not conform to the daily load duration curve.

On-Peak (Model) – Those hours or other periods typically considered periods of higher electrical demand.

Off-Peak (Model) – Those hours or other periods typically considered periods of lower electrical demand.

Regulating device – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

Shortfall – Occurs when an entity does not have enough dispatchable generation to serve the entity’s load.

Tie Line (Model) – A circuit connecting two Model Areas.

26 Attachment AA Resource Adequacy Section 2
SECTION 7: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

- In Service Date,
- Out Service Date,
- From Region Name,
- From Area#, 
- From Area Name,
- From Bus#, 
- From Bus Name,
- From Bus kV,
- To Region Name,
- To Area#,
- To Area Name,
- To Bus#, 
- To Bus Name,
- To Bus kV,
- Metered End (F,T),
- CKT,
- R,
- X,
- B,
- Summer Rating A,
- Summer Rating B,
- Summer Rating C,
- Winter Rating A,
- Winter Rating B,
- Winter Rating C,
- GI (pu),
- BI (pu),
- GJ (pu),
- BJ (pu),
- STATUS (0,1),
- LEN (mi),
- Owner 1,
- Fraction 1,
- Owner 2,
- Fraction 2,
- Owner 3,
- Fraction 3,
- Owner 4,
- Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RMI1,
VMA1,
VMI1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#,
Winding 1 Area Name,
Winding 1 Bus #,
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#,
Winding 2 Area Name,
Winding 2 Bus #,
Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#,
Winding 3 Area Name,
Winding 3 Bus #,
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBASE2-3,
R3-1,
Three Winding Transformer Data Fields - continued

X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus # (CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RMI1,
VMA1,
VMI1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued
Two Terminal DC Tie Data Fields
In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (RJ),
DCVMIN,
CCCITMX,
CCCACC,
IPR REGION NAME,
IPR AREA#, 
IPR AREA NAME,
IPR Bus#, 
IPR BUS NAME,
IPR BUS Kv,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#, 
ICR AREA NAME,
ICR BUS#, 
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#, 
IFR AREA NAME,
IFR BUS#, 
IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields

ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME,
ITR BUS KV,
IDR,
XCAPR,
IPI REGION NAME,
IPI AREA#, 
IPI AREA NAME,
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IDI,
XCAPI

Notes: (1) The data formats must be compatible with PSS®E input requirements.
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
## SECTION 8: APPENDIX II

### UTILIZED IMPEDANCE CORRECTION TABLES

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SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice
Designating MOD-032-1 Data Submittal Assignment

On this _____ day of __________, 20__, _______________ and ________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following:

On ______________, 20__, _______________, Data Owner, and _______________ Data Submitter, entered into an agreement through which _________________ has agreed to submit on behalf of _______________ the (select one):

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2:

________________________________________________________________________________________________________________
________________________________________________________________________________________________________________
________________________________________________________________________________________________________________

The accuracy of the data is the responsibility of the Data Owner. This notice does not shift the compliance obligation from the Data Owner to the Data Submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org.

On behalf of DATA OWNER:

By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: _________________

SPP hereby acknowledges receipt of this notice.

By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: _________________

On behalf of DATA SUBMITTER:

By: ______________________________
Printed Name: _____________________
Title: _____________________________
Date: _________________
SECTION 10: APPENDIX IV SPP MODEL ON DEMAND (MOD) MATRIX

SPP MOD Project Type/Status Matrix

<table>
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<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Description</th>
<th>Applied to this Model Set:</th>
<th>Notes</th>
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<td>SPP-approved Transmission System Upgrade</td>
<td>Must have an NTC for: 1) transmission service request(s); 2) transmission changes originating from the integrated transmission planning (ITP) process; 3) transmission changes originating from the Balanced Portfolio process; 4) transmission changes directed by the high priority study process; 5) transmission changes associated with Sponsored Upgrades.</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Transmission changes that materially-modify the SPP Transmission System. Projects associated with changing the generation or load components interconnected to the SPP Transmission System in accordance with SPP OATT Attachment V and AQ processes, are submitted separately under the “Generation Interconnection” or “Attachment AQ Load” MOD Types.</td>
<td>MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number. Example Prj/Idv Name: 4E5_Patient_Gate_NTC300.prj 4E5_REPC_Build_New_Line_SUS-XXX.prj 4E5_Patient_Gate_PID2250.prj</td>
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<tr>
<td>Planned Transmission System Change</td>
<td>An expected change to the SPP Transmission System that does not yet have or does not require an NTC, including: 1) transmission changes budgeted for or planned by the TO; 2) transmission changes budgeted for by a Transmission Customer or other entity; 3) transmission changes resulting from an emergency (e.g., unplanned equipment failure); 4) transmission, load, or generation changes that otherwise have a strong likelihood or commitment to implement (e.g., load changes not yet approved by Attachment AQ, a GI with an IA but on suspension, a GI without an IA, etc.).</td>
<td>Requested</td>
<td>X X X X X</td>
<td>This MOD Project Type &amp; Status is the default to represent transmission changes expected to be implemented in the future, but are not yet, or will not be, part of any SPP planning processes under Attachment O to the SPP OATT. Do not use this MOD Project Type to submit speculative changes to the transmission model that simply correct basecase system conditions (See MOD Project Type “System Intact Alteration”).</td>
<td>For material changes, Data Submitters shall submit an RMS ticket as a way of notifying SPP. The status for this MOD type will only be changed to “Acknowledged” by Data Submitters after receiving a notification from SPP for inclusion in the model sets.</td>
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<td>Attachment AQ</td>
<td>Changes to load and/or delivery points approved in accordance with Attachment AQ, including any transmission changes associated with the Attachment AQ project (e.g., equipment upgrades, changes to normally-open/closed topology).</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Load changes and transmission changes, including upgrades and changes to normally-open/closed topology, associated with the approved Attachment AQ load modification.</td>
<td>MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, DPA/PIDNS number. Example Prj/Idv Name: 822_NextEra_ADD_Blue_Cloud_Wind_GEN-20YY-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_DPNS-2018-Month-###.prj Example Prj/Idv Name: 525_WFEC_Midwest-Franklin_Rebuild_NTC2002 OR 525_WFEC_Midwest-Franklin_Rebuild_DPA-2018-6Month-###.prj OR 525_WFEC_Midwest-Franklin_Rebuild_DPNS-2018-Month-###.prj 822_NextEra_ADD_Blue_Cloud_Wind_GEN-20YY-###.prj 525_WFEC_Midwest-Franklin_Rebuild_DPNS-2018-Month-###.prj 822_NextEra_ADD_Blue_Cloud_Wind_GEN-20YY-###.prj 525_WFEC_Midwest-Franklin_Rebuild_DPNS-2018-Month-###.prj 822_NextEra_ADD_Blue_Cloud_Wind_GEN-20YY-###.prj</td>
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<tr>
<td>Generation Interconnection</td>
<td>Additions or changes to generating units, including any transmission changes associated with the Generation Interconnection Service project(s), approved in accordance with the Generator Interconnection Procedure (GIP) that: 1) have an executed Interconnection Agreement (IA) or executed Interim Generator Interconnection Agreement (IGIA), and 2) are not suspended.</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Generation changes and transmission changes, including upgrades that may not have been included in the executed IA, associated with the approved GI.</td>
<td>MOD Projects must contain area/owner/zone number, area/owner/zone abbreviated name, NTC/PID/UID number. Example Prj/Idv Name: 525_WFEC_Midwest-Franklin_Rebuild_DPNS-2018-6Month-###.prj 822_NextEra_ADD_Blue_Cloud_Wind_GEN-20YY-###.prj</td>
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<td>Network Status</td>
<td>Changes to the existing SPP Transmission System network topological status only (both placed out-of-service or returned to service).</td>
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<td>Applicable equipment must already be included in the MOD database (constructed, pre-existing) to be placed in- or out-of-service.</td>
<td>Projects with this status will be immediately committed to the MOD base case upon review.</td>
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<td>Modeling Correction</td>
<td>Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD network data.</td>
<td>Update</td>
<td>X X X X X</td>
<td>Projects with this status will not be applied to any models except to those models submitted to MMWG.</td>
<td>Projects with this status will be immediately committed to the MOD base case upon review.</td>
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<tr>
<td>System Intact Alteration</td>
<td>Changes to the transmission model necessary to correct basecase system intact voltage (e.g., to conform to MMWG voltage criteria), thermal criteria violations, or other basecase condition modifications (e.g., addition of an exploratory generating unit which provided resource for shortfalls).</td>
<td>Update</td>
<td>X X X X X</td>
<td>Projects with this status will not be applied to any models except to those models submitted to MMWG.</td>
<td>Projects with this status will be immediately committed to the MOD base case upon review.</td>
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GEOMAGNETIC DISTURBANCE MODELING DATA

Additional modeling data is necessary to supplement the MDWG steady-state models to support geomagnetic disturbance (GMD) analysis. The SPP GMD Model Set combines GMD-related system information (described below) with the MDWG AC-equivalent representation of the SPP transmission system. This composite of modeling data yields a DC-equivalent representation used to calculate geomagnetically-induced current (GIC) flows. These GIC magnitudes can then be applied to the MDWG AC-equivalent model to yield steady-state effects to System voltages and transformer MVAR losses. Appropriate simulations of GMD effects to the BES cannot be achieved without the incorporation of the following modeling information:

Substation Data
Substation modeling data encompasses geographical information related to power system topological information, as represented by the bus-branch model.

**Bus Number (Planning Model):** This is the actual bus from the Planning Model. This bus will be associated with a substation on the Substations sheet.

**Substation Bus Number (Planning Model):** Choose one bus to serve as the substation reference. In other words, the bus number annotated in this field will serve as the geographic reference for the entire substation. The recommendation is for the model Data Submitter to pick the highest voltage bus in a station to serve as this reference.

**Substation DC Grounding Resistance (Ohms):** This can be a measured, calculated, or assumed value for the grounding resistance in Ohms. Caution: do not convert this grounding resistance to per unit Ohms; retain the actual Ohmic quantity. In the unlikely event that a substation/switchyard is ungrounded, the model Data Submitter may enter "-1" here, not zero. Measured values come from ground grid testing, while calculated values are derived from detailed design modeling. When a substation is commissioned or periodic maintenance is performed, grounding integrity or ground grid data is typically collected.

**Grounding Resistance (Method):** This field indicates how the grounding resistance information was obtained.

**Geographic Latitude (decimal degrees):** This latitude will be used for all busses assigned to this station on the "Busses" sheet. Given that the entire SPP footprint is in the Northern Hemisphere, only positive decimal degree values are acceptable for latitude.
Geographic Longitude (decimal degrees): This longitude will be used for all busses assigned to this station on the "Busses" sheet. Caution: longitudes to the west of the Prime Meridian are between 0 and -180°. Given that the entire SPP footprint falls between the 85th west meridian and the 115th west meridian, only negative decimal degree values are acceptable for longitude.

Earth Model (Name): This field assigns the one-dimension earth conductivity model to the geographical location of the substation reference bus. The earth model is based upon the standard earth conductivity models developed by the United States Geological Survey (USGS). The following table shows the cross-reference between the USGS reference and the software code that should be placed in the “Earth Model (Name)” field. On the “1D Earth Model Reference” sheet, a tool is provided to assist in determining the proper earth model by latitude and longitude.

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<td>MID-ATL</td>
<td>PT-1</td>
<td>PT-1</td>
<td>Mid-Atlantic</td>
</tr>
<tr>
<td>NE-1</td>
<td></td>
<td>NE1</td>
<td>New England</td>
</tr>
</tbody>
</table>
### Transformers

The Transformers sheet is intended to collect all of the information necessary to properly determine the magnitude of GIC that will arise within a given transformer. It is important to note that transformer winding resistance data collected from transformer specification sheets or test reports may represent the total resistance of the three phases combined.

While well known to model Data Submitters, the convention for MDWG model data is consistent with most load flow software that requires data be submitted per phase. Therefore, any combined three-phase transformer winding resistance data must be divided by three prior to submitting quantities. Similarly, when DC resistances of transformer windings are unknown (estimated values should only be used when data are unavailable), a reasonable assumption is to substitute actual data with 50% of the per phase copper loss resistance. It is noted that total copper loss resistance may be converted to per phase by dividing by three, and all values should be entered as Ohms, not in per unit base. For example, transformer test reports typically report the total copper loss of a transformer, derived from a short-circuit test, either as a total copper loss power [W] or as the total winding resistance [ohms] calculated from the total copper loss power. In either case, these quantities represent the total copper loss effects of three windings combined and must be divided by three to properly reflect the per phase resistance. The model Data Submitter is expected to provide the following data:

**Core Type**: This indicates the number of cores in transformer core design and is used to calculate transformer reactive power loss from GIC flowing in its winding. This field is only used by the software when a K-factor quantity is not specified by the model Data Submitter for the transformer.

---

27 Also known as a transformer impedance test, a typical transformer short-circuit test is performed by shorting the low-voltage winding and increasing the high-voltage winding voltage until transformer rated current is observed in the high-voltage winding. This test recognizes that core loss is negligible, yielding the resistive losses in the primary winding circuit.
In other words, if you know the K-factor for the transformer (or have a better assumption), enter the quantity in the "GIC Reactive Loss Factor (K-factor)" field and it diminishes the importance of the "Core Type" field. Otherwise, the values for this field are limited to:

<table>
<thead>
<tr>
<th>Code</th>
<th>Core Design Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Three-phase shell configuration</td>
</tr>
<tr>
<td>0</td>
<td>Unknown core design</td>
</tr>
<tr>
<td>1</td>
<td>Three separate single phase cores design</td>
</tr>
<tr>
<td>3</td>
<td>Three phase, 3-legged core configuration</td>
</tr>
<tr>
<td>5</td>
<td>Three phase, 5-legged core configuration</td>
</tr>
<tr>
<td>7</td>
<td>Three phase, 7-legged core configuration</td>
</tr>
</tbody>
</table>

If the core configuration is unknown, stating as such in the Core Type field is acceptable. When this is done, the software will make an assumption for K-factor based upon the voltage level of the highest winding voltage of that transformer. All transformers in the SPP MDWG model series are expected to have vector groups defined, so that T-modeling of transformers in the DC network is permitted.

**Connection Code (CC):** This is the field for the Data Submitter to update the Connection Code shown in the Existing Connection Code (CC) field, if warranted. This field is included because experience has shown that prior model-building efforts may not have focused on this data, but it is critical to GIC modeling. It is suggested that the model Data Submitter review vector group and winding order to ensure proper CC submittal.

**Vector Group:** This is key data required to properly model the grounding characteristics of a transformer. While potentially misleading, most load flow software packages embed the transformer per phase winding configuration information under short-circuit data category. The confusing aspect is that winding configuration is meaningful in situations other than under short-circuit conditions; for example, with GIC that arise from GMD. As a reminder, the Connection Code data contained within the load flow model representation embodies concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation.

**GIC Reactive Loss Factor (K-factor):** The K-factor is an important aggregated assumption that helps formulate the transformer sensitivity to half-cycle saturation that arises from the contribution of GIC. In other words, the K-factor indicates a measure of increased reactive power losses in the transformer when subjected to GICs. The units of K-factor are MVAR per Ampere; the larger the K-factor the larger expected reactive power losses in the transformer. K-factor is used to calculate additional transformer reactive power losses according to:

\[ Q_{\text{loss}} = \text{Effective GIC Winding Current} \times \text{K-Factor}. \]
There is much debate in industry about how to measure, calculate, and assume values for K-factor. In general, if a K-factor is not specified on a transformer data sheet or in test reports, the following table annotates appropriate assumed values. It is noted that the following assumptions for K-factor are consistent with those integrated into the Siemens/PTI software:

<table>
<thead>
<tr>
<th>Core Type Code</th>
<th>Highest Winding kV</th>
<th>K-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Any</td>
<td>0.33</td>
</tr>
<tr>
<td>0</td>
<td>&lt;=200 kV</td>
<td>0.6</td>
</tr>
<tr>
<td>0</td>
<td>&gt; 200kV, &lt;=400kV</td>
<td>0.6</td>
</tr>
<tr>
<td>0</td>
<td>&gt; 400kV</td>
<td>1.1</td>
</tr>
<tr>
<td>1</td>
<td>Any</td>
<td>1.18</td>
</tr>
<tr>
<td>3</td>
<td>Any</td>
<td>0.29</td>
</tr>
<tr>
<td>5</td>
<td>Any</td>
<td>0.66</td>
</tr>
<tr>
<td>7</td>
<td>Any</td>
<td>0.66</td>
</tr>
</tbody>
</table>

**DC Resistance of From, To, and Tertiary Windings (Ohms/Phase):** The preferred value is measured, typically derived from a transformer specification sheet or test report. This data should be the measured DC resistance of single winding at nominal tap and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**From, To, and Tertiary Windings Grounding Resistance (Ohms):** The preferred value is measured or calculated, typically derived from a ground grid design, transformer test report, or other test report. This data should be the measured DC resistance of single winding at nominal tap and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Blocking Device Status (From, To, and Tertiary Windings):** Indicate whether a GIC blocking device is installed and is operational on the From winding in this field. GIC blocking devices on transformer windings are rare.

**DC Resistance of From, To, and Tertiary Windings Blocking Device (Ohms):** Currently, most load flow software tools that support a GIC analysis module assume that if a blocking device is installed and active, that the DC resistance of that block is infinite. In other words, the winding is either blocked from participating in GIC flow or not. It is expected that in future versions GIC analysis modules that software will support an actual DC resistance for the blocking device to more precisely model GIC flow through the transformer winding. Input the known DC resistance of the blocking device in Ohms, if known.
Transformer Model in DC Network: Entered as 0 to represent the transformer according to its vector group, or entered as 1 to represent the transformer as a T-model. **Important note:** given that all transformers in the SPP MDWG model series are expected to have vector groups defined, the model Data Submitter should avoid entering 1 in this field. In future revisions of the MDWG model data collection, this field may be eliminated. However, due to an outstanding PSS®E software ambiguity for symmetric phase shifting transformers, this field is retained.

Symmetric phase shifting transformers modulate real power flow, typically to a narrow specified range. These are represented in the load flow model by two-winding transformer representations that utilize the “MW symmetrical PAR” or “MW asymmetrical PAR” control mode. These transformers should be modeled as the YNa vector group with Connection Codes (CC) 9 or 19, reflecting that the winding 1 impedance represents the zero sequence impedance of the regulating transformer, the winding 2 impedance represents the zero sequence impedance of the series transformer, and the shunt branch represents the tertiary winding impedance. If the symmetric phase shifting transformer is entered this way, the “Transformer Model in DC Network” (TMODEL) should be entered as 0. However, in those rare cases when a vector group is not specified for the symmetric phase shifting transformer, the PSS®E software needs to establish a default for the transformer T-model representation in DC analysis. This is accomplished by entering the “Transformer Model in DC Network” (TMODEL) as 1.

**Shunts**

The Shunts sheet is intended to collect information necessary for modeling direct paths to ground that contribute to the magnitude of GIC flow on the power system. There are two key observations that need to be considered when submitting shunts data for MDWG model data collection. First, Switch Shunt capacitor devices are not considered by GIC analysis software. This is due to the expectation that capacitive shunts are GIC blocks and inductive devices would be intentionally placed out-of-service so as to not exacerbate GIC during GMD events. Second, line reactor devices are very important for modeling GIC. However, the practice of representing line reactors is inconsistent amongst model builders, where some explicitly model line reactor shunts at buses in the transmission line path, while others incorporate the impedance of the line shunt into the data record of the transmission line branch itself. It is important to confirm how line shunts are being modeled. The model Data Submitter is expected to provide the following data:

**From, To Bus Number (Planning Model):** Self-explanatory; where the fixed shunt is located. In the case where the line shunt is modeled as part of the transmission line branch, enter the bus number of the branch terminal end that is closest to the physical location of the line reactor. If line reactors reside at both ends of the branch, make two separate line item entries (e.g., separate rows) to reflect two separate line reactors.

**Line or Bus (Planning Model):** Enter the method of modeling the shunt device, as either explicitly at a bus or as part of a line (branch).

**Located at which end (From, To, or Both):** For line shunts modeled as part of the transmission line branch, enter at which terminal ends the line reactor is installed. Otherwise, leave this field blank.
**Winding Connection Type:** This information is not currently used as part of the analysis, but may be relevant in future assessments. Enter the winding configuration as Wye, Grounded-Wye, or Delta. This information should be annotated on the shunt specification sheet or as part of a test report.

**Shunt DC Resistance (Ohms/Phase):** The preferred value is measured, typically derived from the shunt specification sheet or test report. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Shunt Grounding Resistance (Ohms):** The preferred value is measured or calculated, typically derived from a ground grid design, shunt test report, or other test report. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Branch**

The Branch sheet is intended to reflect the characteristics of the transmission lines that serve as the current-carrying conductors participating in the varying magnetic field, giving rise to GIC. It is noted that most of the information for transmission lines is already part of load flow models. The model Data Submitter is expected to provide the following data:

**Branch Resistance (pu):** Most branch resistances are known in per unit, so an automatic conversion to ohms per phase is included here. The ohms per phase quantity can be entered explicitly in the DC Resistance cell or, if Branch Resistance (pu) is left as zero, the GIC module will use the AC branch resistance already in load flow model. It is important to note: this “Branch Resistance” field refers to the DC branch resistance that will characterize the transmission line in the DC model representation for GIC analysis. For the purpose of the MDWG model data collection, all transmission line conductor DC resistances shall be entered at 50 °C.

For an identical temperature, transmission line branch per phase resistances vary slightly between DC resistance and AC resistance. However, for large diameter transmission line conductors, the difference between AC and DC resistances may exceed 10%, at a common temperature. This is especially important when considering whether a transmission line employs bundled conductors. For the purpose of MDWG model data collection, it is acceptable to use the AC branch resistance already in the load flow model, if the AC resistance is based on 50 °C or less. However, care must be taken when using AC resistances as approximations of the DC resistance, especially when the AC resistance is based on temperatures greater than 50 °C. While conductor resistivity increases approximately linearly with temperature between 20 °C to 75 °C, the difference between DC and AC resistances may vary non-linearly with temperature given other transmission line characteristics, leading to significant differences in resistance. In other words, knowing that transmission line AC resistances are often entered into the load flow models at 25 °C, using this AC resistance as a conservative approximation for DC resistance is acceptable. However, any AC resistance entered into

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28 The Transmission Line Characteristics (TMLC) software and Line Properties Calculator (LineProp) software are common tools used by model Data Submitters to calculate AC transmission line branch impedances. Both of these software packages do not allow any other conductor temperature assumption other than 25 °C, when calculating AC resistance calculation, unless default manufacturer data tables are overwritten. Typical transmission line conductor tables furnished by manufacturers provide AC resistances at 25 °C, 50 °C, and 75 °C.
the load flow model using temperatures greater than 50 °C must be corrected to 50 °C prior to using the quantity as the approximation for DC resistance.

Ultimately, to perform a conservative study of GMD effects, the smaller the transmission line DC resistance, the larger the GIC that will be developed. Therefore, DC resistances entered at 50 °C are preferred. AC resistances corrected to and entered at 50 °C or less are an acceptable alternative.

Real part of total branch GMD-induced electric field (volts): This field is intended to allow a particular branch to experience a higher or lower induced electric field than the uniform field applied to other branches. In other words, if there is a reason to expect a particular transmission line will experience more or less induced field during a benchmark GMD event (line length times the TPL-007-3 reference geoelectric field of 8V/km), enter the alternative real-part electric field in volts. Caution: do not enter zeros into this field unless the transmission line is not intended to participate in the development of an electric field due to GMD. Rare examples of when this may be the case include buried or undersea transmission cable. Leave this field blank to apply the uniform electric field automatically.

Imaginary part of total branch GMD-induced electric field (volts): This field is intended to allow a particular branch to experience a higher or lower induced electric field than the uniform field applied to other branches. In other words, if there is a reason to expect a particular transmission line will experience more or less induced field during a benchmark GMD event (line length times the TPL-007-3 reference geoelectric field of 8V/km), enter the alternative imaginary-part electric field in volts. Caution: do not enter zeros into this field unless the transmission line is not intended to participate in the development of an electric field due to GMD. Rare examples of when this may be the case include buried or undersea transmission cable. Leave this field blank to apply the uniform electric field automatically.

Loads

Note: loads for GMD data submittal are expected to be exceptions and are uncommon! Albeit rare, the possibility exists that a relevant load may be connected at EHV/HV levels that offers a ground path for GIC. Likewise, it may be desirable for a Data Submitter to include data for a solidly-grounded load direct-served through an EHV/HV autotransformer (uncommon), such as with a large industrial load. All loads do not need to be entered into the Loads sheet! The Loads sheet is intended to collect information necessary for modeling the rare direct paths to ground introduced due to load connections that contribute to the magnitude of GIC flow on the power system. The model Data Submitter is expected to provide the following data:

Winding Connection Type: This information is not currently used as part of the analysis, but may be relevant in future assessments. Enter the winding configuration as Wye, Grounded-Wye, or Delta. For loads with a dedicated step-down transformer, this information may be annotated on the step-down transformer specification sheet or as part of a test report for the primary winding (non-autotransformer) or the primary-secondary autotransformer winding configuration.

Load DC Resistance (Ohms/Phase): The Data Submitter should take care when entering this value. Remember, for autotransformers, the common winding (primary and secondary) is likely grounded. When determining the load DC resistance, consider that the actual impedance of the load to ground is connected to the secondary in parallel with the tapped common winding. The preferred value is
measured DC resistance of single phase and adjusted to 75 °C, but the common winding to ground resistance may be a suitable proxy for DC analysis. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Load Grounding Resistance (Ohms):** The preferred value is measured or calculated, typically derived from the step-down transformer test report indicating the transformer neutral grounding. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.
SECTION 12: APPENDIX V MOD-032-1
ATTACHMENT 1

MOD-032-1 – ATTACHMENT 1
The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity\(^{29}\) responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state</th>
<th>dynamics</th>
<th>short circuit</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)</td>
<td>(If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
</tbody>
</table>

1. Each bus [TO]
   a. **nominal voltage**
   b. **area, zone and owner**

2. Aggregate Demand\(^{29}\) [LSE]
   a. **real and reactive power**\(^*\)
   b. **in-service status**\(^*\)

3. Generating Units\(^{30}\) [GO, RP (for future planned resources only)]
   a. **real power capabilities** - gross maximum and minimum values
   b. **reactive power capabilities** - maximum and minimum values at real power capabilities in 3a above
   c. **station service auxiliary load for normal plant configuration** (provide)

1. **Generator** [GO, RP (for future planned resources only)]
2. **Excitation System** [GO, RP (for future planned resources only)]
3. **Governor** [GO, RP (for future planned resources only)]
4. **Power System Stabilizer** [GO, RP (for future planned resources only)]
5. **Demand** [LSE]
6. **Wind Turbine Data** [GO]
7. **Photovoltaic systems** [GO]
8. **Static Var Systems and FACTS** [GO, TO, LSE]
9. **DC system models** [TO]
10. **Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes.** [BA, GO, LSE, TO, TSP]

29 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
<table>
<thead>
<tr>
<th>d. regulated bus* and voltage set point* (as typically provided by the TOP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>e. machine MVA base</td>
</tr>
<tr>
<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
</tr>
<tr>
<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
</tr>
<tr>
<td>h. in-service status*</td>
</tr>
</tbody>
</table>

4. AC Transmission Line or Circuit [TO]
   a. impedance parameters (positive sequence) |
   b. susceptance (line charging) |
   c. ratings (normal and emergency)* |
   d. in-service status* |

5. DC Transmission systems [TO]

6. Transformer (voltage and phase-shifting) [TO]
   a. nominal voltages of windings |
   b. impedance(s) |
   c. tap ratios (voltage or phase angle)* |
   d. minimum and maximum tap position limits |
   e. number of tap positions (for both the ULTC and NLTC) |
   f. regulated bus (for voltage regulating transformers)* |
   g. ratings (normal and emergency)* |
   h. in-service status* |

| Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP] |
7. **Reactive compensation (shunt capacitors and reactors) [TO]**
   a. **admittances (MVars) of each capacitor and reactor**
   b. **regulated voltage band limits* (if mode of operation not fixed)**
   c. **mode of operation (fixed, discrete, continuous, etc.)**
   d. **regulated bus* (if mode of operation not fixed)**
   e. **in-service status***

8. **Static Var Systems [TO]**
   a. **reactive limits**
   b. **voltage set point***
   c. **fixed/switched shunt, if applicable**
   d. **in-service status***

9. **Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]**
SUMMARY OF MOTIONS AND ACTION ITEMS

Action Items:

1. SPP to post approved 2021 MDWG/2022 ITP model build schedule in both pdf and excel format

2. Moses to send out an email to Data Submitters for feedback on things that need to be tested (powerflow, short circuit and dynamics, GMD, etc) before moving to a new version of PSSE. The feedback will then be discussed at a future powerflow focus group meeting

3. Manual task force to review the data coordination language and bring back to the MDWG if still warranted

Motions:

1. Jason Shook made the motion to approve the agenda as modified. Jordan Lamb seconded it. There was no discussion on the motion and it passed unanimously.

2. Scott Schichtl made the motion to approve the previous meeting minutes. Andy Berg seconded it. There was no discussion on the motion and it passed unanimously.

3. John Boshears made the motion to approve the node-breaker modeling language as presented. Holli Krizek seconded it. There was no discussion on the motion and it passed unanimously.
AGENDA ITEM 1 – ADMINISTRATIVE ITEMS

AGENDA ITEM 1A & 1B – CALL TO ORDER AND ANTITRUST STATEMENT

SPP MDWG Chair, Nate Morris, called the meeting to order at 1:07 p.m. with Quorum. SPP Staff Secretary, Moses Rotich, read the anti-trust statement to the group.

AGENDA ITEM 1C & 1D – ATTENDANCE AND PROXIES

The following members attended or were represented by proxy:

<table>
<thead>
<tr>
<th>MDWG Member</th>
<th>Present</th>
<th>Proxy</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nate Morris</td>
<td>YES</td>
<td></td>
<td>Empire District Electric Company, MDWG Chair</td>
</tr>
<tr>
<td>Jerad Ethridge</td>
<td>YES</td>
<td></td>
<td>Oklahoma Gas &amp; Electric, MDWG Vice-Chair</td>
</tr>
<tr>
<td>Charles Aleman</td>
<td>YES</td>
<td></td>
<td>Golden Spread Electric Cooperative</td>
</tr>
<tr>
<td>Andrew Berg</td>
<td>YES</td>
<td></td>
<td>Missouri River Energy Services</td>
</tr>
<tr>
<td>Preston Blinsky</td>
<td>YES</td>
<td></td>
<td>Basin Electric Power Cooperative</td>
</tr>
<tr>
<td>John Boshears</td>
<td>YES</td>
<td></td>
<td>City Utilities of Springfield</td>
</tr>
<tr>
<td>Joe Fultz</td>
<td>YES</td>
<td></td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td>Jeremy Harris</td>
<td>YES</td>
<td></td>
<td>KCP&amp;L and Westar, Evergy Companies</td>
</tr>
<tr>
<td>Steve Hohman</td>
<td>YES</td>
<td></td>
<td>Omaha Public Power District</td>
</tr>
<tr>
<td>Holli Krizek</td>
<td>YES</td>
<td></td>
<td>Western Area Power Administration</td>
</tr>
<tr>
<td>Jordan Lamb</td>
<td>YES</td>
<td></td>
<td>East River Electric Power Cooperative</td>
</tr>
<tr>
<td>Reené Miranda</td>
<td>YES</td>
<td>Aravind Chellappa</td>
<td>YES</td>
</tr>
<tr>
<td>Alex Mucha</td>
<td>YES</td>
<td></td>
<td>Oklahoma Municipal Power Authority</td>
</tr>
<tr>
<td>Scott Rainbolt</td>
<td>YES</td>
<td></td>
<td>American Electric Power</td>
</tr>
<tr>
<td>Scott Schichtl</td>
<td>YES</td>
<td></td>
<td>Arkansas Electric Cooperative Company</td>
</tr>
<tr>
<td>Jason Shook</td>
<td>YES</td>
<td></td>
<td>GDS Associates</td>
</tr>
<tr>
<td>Liam Stringham</td>
<td>YES</td>
<td></td>
<td>Sunflower Electric Power Corporation</td>
</tr>
<tr>
<td>Sunny Raheem</td>
<td>YES</td>
<td>Moses Rotich</td>
<td>YES</td>
</tr>
</tbody>
</table>
### Additional Guests:

<table>
<thead>
<tr>
<th>Guests</th>
<th>Company</th>
</tr>
</thead>
<tbody>
<tr>
<td>Josh Hesselbein</td>
<td>Arkansas Electric Cooperative Corporation</td>
</tr>
<tr>
<td>David Zhong, Martin Green</td>
<td>American Electric Power</td>
</tr>
<tr>
<td>Adam Mummert</td>
<td>Burns and Mcdonnell</td>
</tr>
<tr>
<td>Conner Sweet, Jerry Bradshaw, Jeff Knottke</td>
<td>City Utilities of Springfield</td>
</tr>
<tr>
<td>Jeff Crites</td>
<td>Empire District Electric Company</td>
</tr>
<tr>
<td>Leonardo Villa, Matthew Keenan</td>
<td>Enel Power</td>
</tr>
<tr>
<td>Pallab Datta, Ryan Baysinger</td>
<td>Evergy Companies</td>
</tr>
<tr>
<td>Diego Toledo, Dona Parks</td>
<td>Grand River Dam Authority</td>
</tr>
<tr>
<td><a href="mailto:TSell@ITCtransco.com">TSell@ITCtransco.com</a></td>
<td>ITC Transco</td>
</tr>
<tr>
<td>Calvin Coates</td>
<td>Kansas City Board of Public Utilities</td>
</tr>
<tr>
<td>Edin Terzic, <a href="mailto:Esun@les.com">Esun@les.com</a></td>
<td>Lincoln Electric System</td>
</tr>
<tr>
<td>Armin Sehic, Bruce Doll</td>
<td>Municipal Energy Agency of Nebraska</td>
</tr>
<tr>
<td>Dustin Betz</td>
<td>Nebraska Public Power District</td>
</tr>
<tr>
<td>Kim McClafferty, Mark Mallard</td>
<td>Northwestern</td>
</tr>
<tr>
<td>Daryl Huslig, <a href="mailto:sattersj@oge.com">sattersj@oge.com</a></td>
<td>Oklahoma Gas and Electric</td>
</tr>
<tr>
<td>Paul Vovk, Tom Mayhan</td>
<td>Omaha Public Power District</td>
</tr>
<tr>
<td>Becca McCann, Brooke Keene, Eddie Watson, Hugh Benfer, Kimberly Woods, Lottie Richardson, Michael Odom, Moses Rotich, Shahrokh Akhlaghi, Zach Sabey</td>
<td>Southwest Power Pool, Inc.</td>
</tr>
<tr>
<td>Scott Mijin</td>
<td>Southwest Power Administration</td>
</tr>
<tr>
<td>Aravind Chellappa, Frank Favela</td>
<td>Southwestern Public Service</td>
</tr>
<tr>
<td>Tanner New</td>
<td>Sunflower Electric Cooperative</td>
</tr>
<tr>
<td>Hummad Malhi, Joe Williams, Josh Turner</td>
<td>Western Farmers Electric Cooperative</td>
</tr>
<tr>
<td>Brianna Haug, Gayle Nansel, Chris Colson</td>
<td>Western Area Power Administration</td>
</tr>
</tbody>
</table>
AGENDA ITEM 1E – AGENDA REVIEW *(APPROVAL ITEM)*

Nate Morris asked the group whether they had any modifications to the agenda. No one proposed changes to the agenda.

**Motion: Jason Shook made the motion to approve the agenda as modified. Jordan Lamb seconded it. There was no discussion on the motion and it passed unanimously.**

Material: JUNE03_Attach1 - 1e. MDWG Meeting Agenda 20200603.docx

Nate asked whether the group had any comments on the availability and deliverability of meeting material. He noted that as far as he was concerned, the material was posted on time.

AGENDA ITEM 1F – PREVIOUS MAY 13 MEETING MINUTES *(APPROVAL ITEM)*

Nate Morris asked the group whether they had any proposed changes for the previous meeting minutes. There were no comments.

**Motion: Scott Schichtl made the motion to approve the previous meeting minutes. Andy Berg seconded it. There was no discussion on the motion and it passed unanimously.**

Material: JUNE03_Attach2 - 1f. May 13 2020 MDWG Meeting Minutes.pdf
AGENDA ITEM 2 – REVIEW OF PAST ACTION ITEMS

Moses gave a summary of certain action items:

- Action Item 31 - reach out to MISO modeling for bus mapping data for short circuit model build. *(In progress)*
- Action Item 69 – justification for branch impedance to be discussed in SCFG *(in progress)*
- Action Item 83 – update from Brooke and Michael, updates were made in retirement workbook and added comments field *(complete)*
- Action Item - staff to send representation to MOPC *(complete)*
- Action Item 89- send email to group regarding manual language approval *(complete)*

For action item 89, Jerad asked if the manual had been posted already or whether staff was waiting on more updates. Michael said that the newest version will be posted once all updates have been made to the manual.

AGENDA ITEM 3 – TASK FORCE/FOCUS GROUP UPDATES

AGENDA ITEM 3A – MDWG POWERFLOW FOCUS GROUP

Moses Rotich gave an update on the group’s activities. He highlighted the following items that were discussed at the last powerflow focus group meetings:

- Discussed PSSE version to determine which version utilize between PSSE v34.7 and v34.8. The group recommended using PSSE v34.7 in the 2021 series model build.
- Discussed model build schedule approved by SPP management and took some feedback
- Discussed draft node-breaker language before taking it to the MDWG manual task force for further discussion. He noted that this language was an approval item in the meeting and would be covered later in the agenda.
- Discussed the MMWG language change on the definition of the light load model and addition of the minimum load models. After much deliberation at the powerflow focus group meeting, the group decided on not changing the SPP definition of light load.
- Future meetings starting in July will be changed to once a month
AGENDA ITEM 3B – MDWG DYNAMIC FOCUS GROUP

Shahrokh gave an update. He said the group meetings now occur every 3 months but in the last one, they discussed DERs and ESRs and proposed language that was sent to the manual task force. He also noted that Marc Moor had resigned as chair of the group and that they were seeking a volunteer to chair it. Nate then urged those interested in chairing the group to reach out to him or Jerad.

AGENDA ITEM 3C – MDWG GENERATION DISPATCH FOCUS GROUP

Steve gave an update on the group’s activities. He highlighted some of the issues being evaluated by the group:

- TPL-001 requirement for known commitments
- Input data sources and ease of sharing that data
- NITSA interpretation by SPP
- Staff investigating sharing of ABB data.....licenses Vs NDAs
- Shortfall process under proposed super BA dispatch approach
- Roadmap for finalizing assumptions and benchmarking new dispatch

AGENDA ITEM 3D – MDWG SHORT CIRCUIT FOCUS GROUP

Michael gave an update on the group’s activities. He noted that they had discussed DERs/ESRs and are working on getting some companies to present on ESRs in future meetings. He noted that the next SCFG call is on August 11th, 2020.

AGENDA ITEM 4 – ITP GEN/LOAD DATA DEPENDENCIES FROM MDWG SCHEDULE DEADLINES

Brooke gave an educational session on the ITP gen and load review and its dependencies on the MDWG schedule. During discussion, Andy Berg asked about the 2 resource plans, “Are they just informational platforms to perform futures for the ITP or is there more to it?” Brooke answered that resource plan generation is not included in the base reliability models. They are intended for transmission planning studies. She said the resource adequacy standards help determine how much generation to include in the economic models. Michael also added that the table on slide 6 is all in the context of ITP models and doesn't affect attachment AA.
Chris Colson then made a comment germane to the MDWG; economic load and gen review might be done by different people in the same company and same data can be submitted to SPP in a different ways such as Pmax/Pmin values that can be different for the economic models as opposed to the powerflow models. Brooke then mentioned that generation capacities for gen review are initially populated by vendor data so model builders need to review and update this information accordingly.
AGENDA ITEM 5 – 2021 MDWG / 2022 ITP ACTIVITIES

AGENDA ITEM 5A – SCHEDULE REVIEW

Moses presented an overview of the schedule. He went through the presentation before pulling up the schedule in excel format. He noted the major milestones and deadlines on the schedule, the MOD and PSSE versions to be utilized for the upcoming model build series, and the inclusion of updates based on lessons learned from the previous model build. He then mentioned that there was a thorough SPP internal review of the schedule to make sure that it aligned with some of the other processes that have dependencies on the data being collected through the powerflow models. He also noted the last chance to submit certain kinds of data updates in order to avoid impacting other process milestones and encouraged all Data Submitters to do their best to meet these deadlines. After the presentation, Moses solicited feedback from the group on the schedule and noted that the schedule will be presented as an approval meeting in the June 11, 2020 MDWG meeting. Several minor improvements were proposed by the group such as: addition of MOD and PSSE versions, font/color code consistency, calendar (.ics) version of schedule, addition of ITP finalization for consistency and posting of both a pdf and excel version of the schedule for easy filtering.

**Action Item:** SPP to post approved 2021 MDWG/2022 ITP model build schedule in both pdf and excel format

Chris Colson then commented that he wanted to bring up one more time the need to possibly consider PSSE version 35. He said that they had downloaded PSSE v35.1 yesterday and had done some benchmarking against v34.7 (powerflow and short circuit) but hadn’t done any dynamics testing. As an end-user, he noted that PSSE v34.7 will not be useable for GMD studies based on some updates in v35.1. John Turner then commented that it would be good if SPP can make a script that details differences between two PSSE versions and bring results before the MDWG. Eddie Watson also commented that SPP had reviewed PSSE v35 but might not be looking to move to it at this time.

**Action Item:** Moses to send out an email to Data Submitters for feedback on things that need to be tested (powerflow, short circuit and dynamics, GMD, etc) before moving to a new version of PSSE. The feedback will then be discussed at a future powerflow focus group meeting.

AGENDA ITEM 5A – MODEL SELECTION REVIEW

Michael Odom presented. There were no questions after this presentation.

AGENDA ITEM 6 – BREAK
AGENDA ITEM 7 – MDWG MANUAL LANGUAGE

AGENDA ITEM 7A – DATA COORDINATION (APPROVAL ITEM)

Michael presented on this item. Jerad Ethridge commented that if a GO sent data to SPP, the interconnecting TO would also be copied on it. He then added that it is always good to keep TOs informed of impacting changes going into the models. After some further deliberation, Nate solicited a motion but no one was willing to make one. As such, Nate asked the manual task force to review this language again.

**Action Item:** Manual task force to review the data coordination language and bring back to the MDWG if still warranted.

AGENDA ITEM 7B – NODE BREAKER (APPROVAL ITEM)

Michael Odom presented on this language. Nate asked whether any in the manual task force or powerflow focus group had any comments both in support or disagreement of the language. Jeremy commented that ratings A, B and C in other sections need to be updated to the new PSSE v34 ratings. Michael noted that this will be done in the next MDWG meeting.

**Motion:** John Boshears made the motion to approve the node-breaker modeling language as presented. Holli Krizek seconded it. There was no discussion on the motion and it passed unanimously.

Material: JUNE03_Attach2 - 7. SPP Model Development Procedure Manual 2020 v4.0 June 2020_Pending.docx

AGENDA ITEM 8 – MDWG LEADERSHIP UPDATE

Nate gave an update on MDWG leadership. He said that he would step down as chair effective after this meeting and thanked the group for their camaraderie and support. He said that the vice chair, Jerad Ethridge, would take over until the chair is officially voted. He hoped that as he stepped down, he was leaving the group in a better place than when he took over. Eddie then took a moment to thank Nate for his leadership to the group and SPP staff. Sunny also took some time from his vacation to thank Nate for his leadership and leading the group to a state where the models have been posted on time for the past 3 years. He also commented that he looked forward to working with Jerad. Jerad then thanked Nate for making the group enjoyable. He also noted that Nate had wanted to mention this in-person but because of COVID-19, he wasn’t able to. Eddie then extended an invitation for Nate to show up to the next MDWG face-face meeting whenever travel resumes again and face-face meetings are able to be held.
Not allowing to be outdone, and close to tears, Scott Rainbolt thanked Nate for his leadership as well and voiced support for Jerad. He thanked Nate for steadying the ship and making sure that models are posted on time.
AGENDA ITEM 9 – SUMMARY OF ACTION ITEMS

Moses summarized the action items captured during the meeting:

1. SPP to post approved 2021 MDWG/2022 ITP model build schedule in both pdf and excel format

2. Moses to send out an email to Data Submitters for feedback on things that need to be tested (powerflow, short circuit and dynamics, GMD, etc) before moving to a new version of PSSE. The feedback will then be discussed at a future powerflow focus group meeting

3. Manual task force to review the data coordination language and bring back to the MDWG if still warranted
AGENDA ITEM 10 – DISCUSSION OF FUTURE MEETINGS

Nate asked whether the MDWG workshop meeting in August is still scheduled as an in-person meeting or webex. Sunny answered that since SPP will lift its travel ban around August 1st, the meeting would most likely be a webex.

AGENDA ITEM 11 – ADJOURN

Nate Morris adjourned the meeting at 4:00 pm (CDT).

Respectfully Submitted,

Moses Rotich
Secretary
Attachments
JUNE03_Attach1 - 1e. MDWG Meeting Agenda 20200603.docx
JUNE03_Attach2 - 1f. May 13 2020 MDWG Meeting Minutes.pdf
JUNE03_Attach3 - 7. SPP Model Development Procedure Manual 2020 v4.0 June 2020_Pending.docx
**Southwest Power Pool, Inc.**  
**TRANSMISSION WORKING GROUP**  
**Action Item Status Report**

<table>
<thead>
<tr>
<th>Item</th>
<th>Action Item</th>
<th>Date Originated</th>
<th>Status</th>
<th>Comments/Updates</th>
<th>Owner</th>
</tr>
</thead>
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<tr>
<td>1.0</td>
<td>SPP Staff to send out Doodle poll for meeting availabilities on March 9th, 15th, and 16th.</td>
<td>March 1, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Michael and MDWG Short Circuit Focus Group</td>
</tr>
<tr>
<td>2.0</td>
<td>SPP Staff will continue to identify ways to reach out to the 1st tier entities in a more effective way.</td>
<td>March 9, 2018</td>
<td>Completed</td>
<td>Staff coordinating with MISO and MISO TTOPs for short circuit data</td>
<td>Staff: Moses &amp; Sunny</td>
</tr>
<tr>
<td>3.0</td>
<td>SPP Staff to conduct surveys for availability of MDWG meetings provide a preliminary agenda.</td>
<td>March 9, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Moses &amp; Sunny</td>
</tr>
<tr>
<td>4.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>March 9, 2018</td>
<td>Completed</td>
<td>Staff reached out to GlobalScape to determine solution for log out issue</td>
<td>Staff: Moses &amp; Sunny</td>
</tr>
<tr>
<td>5.0</td>
<td>SPP Staff to send out Doodle poll for meeting availability on mid-May for a possible Face-To-Face Meeting and provide a preliminary agenda.</td>
<td>May 9, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Michael and MDWG Manual Task Force</td>
</tr>
<tr>
<td>6.0</td>
<td>SPP Staff to follow-up on external SPP DocuCode script</td>
<td>May 9, 2018</td>
<td>Completed</td>
<td>The acceptable list can be found on the NERC DAMS website SAMS Reference Materials NERC Acceptable Model List</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>7.0</td>
<td>SPP Staff to conduct surveys for availability of MDWG meetings provide a preliminary agenda.</td>
<td>May 9, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Moses &amp; Sunny</td>
</tr>
<tr>
<td>8.0</td>
<td>SPP Staff to work on setting up 2019 MDWG dynamic project GlobalScape folders prior to the project starting.</td>
<td>December 6, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Michael and MDWG Model Dispatch Group</td>
</tr>
<tr>
<td>9.0</td>
<td>SPP Staff to coordinate with SPP GI for feedback on including standard library models language in the GIA.</td>
<td>September 6, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>10.0</td>
<td>SPP Staff to check to see if the SPP market registered units can be shared with Transmission Owners and Transmission Staff and MDWG Model Dispatch Group</td>
<td>September 6, 2018</td>
<td>In Progress</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>11.0</td>
<td>SPP Staff: Michael and MDWG Short Circuit Focus Group</td>
<td>September 6, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>12.0</td>
<td>MDWG Manual Task Force manual language changes</td>
<td>May 9, 2018</td>
<td>Completed</td>
<td>Continuous action item. MDWG Manual v5.0 approved and posted</td>
<td>Staff: Sunny</td>
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<tr>
<td>13.0</td>
<td>SPP Staff to send out NERC acceptable dynamic model list</td>
<td>May 9, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Michael and MDWG Manual Task Force</td>
</tr>
<tr>
<td>14.0</td>
<td>SPP Staff to compare similar 2018 seasonal models</td>
<td>May 9, 2018</td>
<td>Completed</td>
<td>Comparisons located on GlobalScape at: Modeling (CEII, RSD) MDWG Meetings MDWG 2018-8-2</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>15.0</td>
<td>SPP Staff to work on developing on-boarding material</td>
<td>May 9, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>16.0</td>
<td>MDWG Manual TF to review language adding negative sequence data to the branch section.</td>
<td>May 9, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>17.0</td>
<td>SPP Staff to update action item list for active items prior to March 2018</td>
<td>June 7, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>18.0</td>
<td>SPP Staff to provide concern related to approved model selection list</td>
<td>June 7, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>19.0</td>
<td>Chairman, Vice-Chairman, and Staff Secretary to provide draft Charter membership language.</td>
<td>June 7, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>20.0</td>
<td>SPP Staff to post-updated MDWG Manual with approved language</td>
<td>June 7, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
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<tr>
<td>21.0</td>
<td>Data Submitters to provide EST enhancements for consideration in MDWG prioritization list.</td>
<td>June 7, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
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<tr>
<td>22.0</td>
<td>Comply with Reduction Effort (Comply Year 3 definition)</td>
<td>June 7, 2018</td>
<td>Completed</td>
<td>Discussed at May 2nd and 20th 2019 meetings</td>
<td>Staff: Sunny &amp; Moses</td>
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<tr>
<td>23.0</td>
<td>Take-updated Dynamic Data Format Section language back to the MDWG Manual Task Force for additional discussion</td>
<td>September 9, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
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<tr>
<td>24.0</td>
<td>Staff to coordinate with SPP GI for feedback on including standard library models language in the GIA.</td>
<td>September 9, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>25.0</td>
<td>Sunny will send out the working MDWG Charter Guidance document to the group in particular Marc Moor and Jason Shook for further updating to be presented as an approval item at the November MDWG conference call.</td>
<td>October 4, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
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<tr>
<td>26.0</td>
<td>Sunny will solicit feedback for Membership for the new open seats.</td>
<td>October 4, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>27.0</td>
<td>SPP Staff will solicit members to send in 3-5 worse events to benchmark against.</td>
<td>October 4, 2018</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
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<tr>
<td>28.0</td>
<td>MDWG Power Flow Focus Group to look at MDWG Dispatching Methodology</td>
<td>November 1, 2018</td>
<td>In Progress</td>
<td>MDWG Model Dispatch Group created to address the model improvement effort</td>
<td>MDWG Model Dispatch Group</td>
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<tr>
<td>29.0</td>
<td>SPP Staff to reach out to MDWG modeling staff to gather the bus mapping data.</td>
<td>December 6, 2018</td>
<td>Completed</td>
<td>In-progress until posting. Updated EIST manual will be posted on September 20th.</td>
<td>Staff: Moses</td>
</tr>
<tr>
<td>30.0</td>
<td>SPP Staff to reach out to GOs to increase awareness about the annual on-boarding event</td>
<td>January 9, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Michael</td>
</tr>
<tr>
<td>31.0</td>
<td>SPP Staff to send MDWG manual data from Siemens</td>
<td>January 9, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny &amp; Moses</td>
</tr>
<tr>
<td>32.0</td>
<td>SPP Staff to send SPP-Staff to MDWG-Staff to GIA model language for Siemens</td>
<td>January 9, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny &amp; Moses</td>
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<tr>
<td>33.0</td>
<td>SPP Staff to send out Doodle poll for meeting availability on mid-May for a possible Face-To-Face Meeting and provide a preliminary agenda.</td>
<td>March 9, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny &amp; Moses</td>
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<td>34.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>March 9, 2019</td>
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<td>35.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>March 9, 2019</td>
<td>Completed</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>36.0</td>
<td>SPP Staff to send out Doodle poll for meeting availability on mid-May for a possible Face-To-Face Meeting and provide a preliminary agenda.</td>
<td>May 9, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny &amp; Moses</td>
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<td>37.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
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<td>38.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
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<td>39.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
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<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>42.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>43.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>44.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>45.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
<td>Completed</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>46.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>47.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
<td>Completed</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>48.0</td>
<td>SPP Staff to conduct surveys on the MDWG meeting schedules.</td>
<td>May 9, 2019</td>
<td>Completed</td>
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<td>Staff: Sunny &amp; Moses</td>
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<td>Item</td>
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<td>Date Originated</td>
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<td>Comments/Updates</td>
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</tr>
<tr>
<td>49</td>
<td>Staff release SPP developed EHV Node-Breaker model with the next week on GlobalScape.</td>
<td>June 6th, 2019</td>
<td>Completed</td>
<td>SPP powerflow focus group determined test plan including a data request template. SPP modeling sent out a data request for short modeling on 8/2/2019. Benchmarking will be conducted on the 2019 Series MIDWG power flow model.</td>
<td>Moses &amp; MDWG Power Flow Focus Group</td>
</tr>
<tr>
<td>50</td>
<td>MIDWG powerflow focus group determined test plan including a data request template. SPP modeling sent out a data request for short modeling on 8/2/2019. Benchmarking will be conducted on the 2019 Series MIDWG power flow model.</td>
<td>June 6th, 2019</td>
<td>Completed</td>
<td>5/19/2020: The powerflow focus group performed a benchmark of short modeling based on the proposed language and will present its findings and recommendation to the April MDWG meeting. Additionally, the results were discussed with other SPP Planning groups to gather any additional feedback on the proposed language.</td>
<td>Staff and MDWG Power Flow Focus Group</td>
</tr>
<tr>
<td>51</td>
<td>Members to provide additional feedback for machine SC armature resistance language for MIDWG manual revisions</td>
<td>June 6th, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Lottie</td>
</tr>
<tr>
<td>52</td>
<td>Staff to determine if MIDWG-1 mapping data can be shared as part of the unacceptable differences</td>
<td>June 13th, 2019</td>
<td>Completed</td>
<td>MIDWG-1 data for each data submitting entity can be shared with appropriate SPP EHV NDA</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>53</td>
<td>Staff to determine if EDIFT notifications can be disabled or limited to specific submitters</td>
<td>June 13th, 2019</td>
<td>Completed</td>
<td>Staff: Moses</td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Staff to determine if EDIFT notifications can be disabled or limited to specific submitters</td>
<td>June 13th, 2019</td>
<td>Completed</td>
<td>SPP IT added this feature as an enhancement list and will be testing and releasing in a future release</td>
<td>Staff: Moses</td>
</tr>
<tr>
<td>55</td>
<td>Staff &amp; SPP Customer Relations to discuss the addition of MIDWG and/or TDR RMS Quick Pick</td>
<td>June 13th, 2019</td>
<td>Completed</td>
<td>Quick pick information sent to SPP Customer Relations. Quick pick review and implementation projected by end of September</td>
<td>Staff: Kim</td>
</tr>
<tr>
<td>56</td>
<td>Send out digital MDWG workshop survey to participants</td>
<td>June 13th, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>57</td>
<td>Can Staff release executable CheckOut and Model Compare automation to members</td>
<td>June 13th, 2019</td>
<td>Completed</td>
<td>Draft disclaimer being drafted. Staff working on executable version of code. Staff might request member testers in the near future.</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>58</td>
<td>Survey to updated MDWG via email on MIDWG membership nomination and selection</td>
<td>July 11th, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>59</td>
<td>Survey to email updated WebEx for each call for the rest of 2019</td>
<td>July 11th, 2019</td>
<td>Completed</td>
<td>Completed via email on Monday, July 15, 2019</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>60</td>
<td>Staff to reprint the series Power Flow and Short-Circuit Schedule with the updated PSSE version</td>
<td>August 8th, 2019</td>
<td>Completed</td>
<td>Staff: Moses</td>
<td></td>
</tr>
<tr>
<td>61</td>
<td>Michael to provide language comparison between the manual versions</td>
<td>August 8th, 2019</td>
<td>Completed</td>
<td>Post compared to GlobalScape</td>
<td>Staff: Michael</td>
</tr>
<tr>
<td>62</td>
<td>Staff to review the MIDWG-1 presentations, report, and results.</td>
<td>September 12th, 2019</td>
<td>Completed</td>
<td>Posted as a background materials for 10/12/2020 meeting and email on 10/19/2019</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>63</td>
<td>Staff to schedule meeting to go over MIDWG-1 mapping</td>
<td>September 13th, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>64</td>
<td>Staff to post final dynamic models with recent acceptable model updates the following week</td>
<td>September 18th, 2019</td>
<td>Completed</td>
<td>Posted at: Modeling (EDS, RE5) → MIDWG Series → MIDWG Model Development Procedure Manual Comparison</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>65</td>
<td>Staff to post the MDWG manual comparison to GlobalScape.</td>
<td>October 22, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>66</td>
<td>Nate to reach out to task force members for leadership opportunity.</td>
<td>October 22, 2019</td>
<td>Completed</td>
<td>Steve Hoffman accepted lead position for the MDWG Model Dispatch Focus Group</td>
<td>Nate</td>
</tr>
<tr>
<td>67</td>
<td>Staff to research if ODMS can be purchased for use in Node-Breaker modeling.</td>
<td>October 22, 2019</td>
<td>Completed</td>
<td>Note: Requested test case data and scope of application from vendor</td>
<td>Staff: Michael</td>
</tr>
<tr>
<td>68</td>
<td>Staff to determine if MIDWG-1 mapping data can be shared as part of the unacceptable differences</td>
<td>October 22, 2019</td>
<td>Completed</td>
<td>Staff: Michael &amp; Hugh</td>
<td></td>
</tr>
<tr>
<td>69</td>
<td>Staff to send out revised 2020 series MDWG dynamic model build schedule adjusted for an earlier MDWG finalization date within two weeks.</td>
<td>October 22, 2019</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>70</td>
<td>Staff to automate the automation GlobalScape path to MDWG</td>
<td>October 22, 2019</td>
<td>Completed</td>
<td>Posted at: Modeling (EDS, RE5) → MIDWG Series → MIDWG Model Development Procedure Manual Comparison</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>71</td>
<td>Staff to notify visibility settings for applicable tie line entries in EEDT</td>
<td>December 9, 2019</td>
<td>Completed</td>
<td>Staff reviewed and communicated changes to the applicable entities on the last week of Jan 2020</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>72</td>
<td>Staff to communicate to upper SPP management about collective feedback from the Age and Condition Discussion. Additionally note the summary of the discussion within the TWS report.</td>
<td>January 22, 2020</td>
<td>In Progress</td>
<td>Staff communicated the MDWG feedback to SPP upper management. The feedback was also included in the MIDWG report for TWS. Transmission Planning staff preference is to not go back in time for the 2019 TIP constraints. Instead, TWS requested Jay to bring aStrange to proposal for how the data will be used. Staff believes the draft proposal is a more efficient direction forward for this effort.</td>
<td>Staff: Hugh</td>
</tr>
<tr>
<td>73</td>
<td>Staff to follow up on how short circuit tie line data with ACCS is applied</td>
<td>January 22, 2020</td>
<td>Completed</td>
<td>Staff is researching particular issues.</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>74</td>
<td>Staff should review the accuracy of the TWS tie line data before the 2/7 member deadline</td>
<td>January 22, 2020</td>
<td>Completed</td>
<td>Staff reviewed and communicated changes to the applicable entities on the last week of Jan 2020</td>
<td>Staff: Library &amp; Alves</td>
</tr>
<tr>
<td>75</td>
<td>Staff to update the manual task force meeting time by 1/1</td>
<td>January 22, 2020</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>76</td>
<td>Staff to send out notice for ranking EEDT enhancement list.</td>
<td>January 22, 2020</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>77</td>
<td>Moses to include language about aux load in the ITP models in the posting email</td>
<td>February 13, 2020</td>
<td>Completed</td>
<td>Included in March 9, 2020 posting email</td>
<td>Staff: Moses</td>
</tr>
<tr>
<td>78</td>
<td>Moses to send out an email to Data Submitters about the draft date for corrections</td>
<td>March 19, 2020</td>
<td>Completed</td>
<td>Email notification was sent to all Data Submitters</td>
<td>Staff: Moses</td>
</tr>
<tr>
<td>79</td>
<td>Moses to discuss internally with other SPP staff and MDWG on the modeling of units and Clark unit retirements and get back with WAPA</td>
<td>March 19, 2020</td>
<td>Completed</td>
<td>The Lewis and Clark retirements were captured in the 2010 - 2023 models as proposed by WAPA.</td>
<td>Staff: Moses</td>
</tr>
<tr>
<td>80</td>
<td>Staff to post the final models and notify Data Submitters</td>
<td>March 19, 2020</td>
<td>Completed</td>
<td>The models were posted and Data Submitters reminded on 3/22/2020</td>
<td>Staff: Moses</td>
</tr>
<tr>
<td>81</td>
<td>Staff (Lottie Richardson) to send out meeting notification for the Generation Dispatch Focus Group meeting.</td>
<td>March 27, 2020</td>
<td>Completed</td>
<td>Staff communicated MDWG Dispatch Focus Group Meeting on 3/27/2020</td>
<td>Staff: Lottie</td>
</tr>
<tr>
<td>82</td>
<td>Staff (Michael Odom) post final MDWG short circuit models within a week.</td>
<td>March 27, 2020</td>
<td>Completed</td>
<td></td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>83</td>
<td>Staff to explain planned retirement data collection improvements to accommodate refueling</td>
<td>March 30th, 2020</td>
<td>Completed</td>
<td>Updates were made to the Flame Generation Retirement Workload to allow one unit to be modeled, but added a comments field to explain when the outower did or will take place...:as in: Unit Conversion from I Gas to I Gas 01/1/2019</td>
<td>Staff: Koreck &amp; Michael</td>
</tr>
<tr>
<td>84</td>
<td>Staff (Moses &amp; Sunny) to reach out to SPP EMS modeling staff to see if an EMS education session can be provided</td>
<td>April 6th, 2020</td>
<td>Completed</td>
<td>Completed EMS staff provided education in April MDWG PFPP meeting</td>
<td>Staff: Moses &amp; Sunny</td>
</tr>
<tr>
<td>85</td>
<td>Staff (Koreck) to provide the full EEDT enhancement list to the group</td>
<td>April 6th, 2020</td>
<td>Completed</td>
<td>Staff uploaded the full EEDT list to GlobalScape and notified MDWG of the upload</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>86</td>
<td>MIDWG Manual Task Force to review the union modeling section and update it to match the latest template</td>
<td>April 6th, 2020</td>
<td>Completed</td>
<td></td>
<td>Staff: Lottie &amp; Moses</td>
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<tr>
<td>87</td>
<td>Staff (Sunny Rahem) send MIDWG representation solicitation to SPP MOFC contacts after the MDWG meeting</td>
<td>May 11, 2020</td>
<td>Completed</td>
<td>Email sent with deadline of May 15, 2020</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>88</td>
<td>Staff (Sunny Rahem) to send email to the group about manual language approval and February 13, 2020 meeting minutes changes for approval in order to solicit a motion by Friday</td>
<td>May 11, 2020</td>
<td>Completed</td>
<td>Email sent for MDWG language and February 13, 2020 meeting minutes added. Both items included in May 13, 2020 meeting minutes package.</td>
<td>Staff: Sunny</td>
</tr>
<tr>
<td>89</td>
<td>SPP to post approved 2021 MIDWG/2022 ITP model build schedule in both pdf and excel format</td>
<td>June 3, 2020</td>
<td>Completed</td>
<td>6/30/2020: SPP posted the schedule in both pdf and excel format on the SPP website. Additionally, outlook calendar formats (.ics) of schedule were also attached in the schedule posting email to all Data Submitters.</td>
<td>Staff: Kim</td>
</tr>
<tr>
<td>90</td>
<td>Moses to send out an email to Data Submitters for feedback on things that need to be tested (powerflow, short circuit and dynamics) before moving to a new version of PSE. The feedback will then be discussed at the powerflow focus group.</td>
<td>June 3, 2020</td>
<td>In Progress</td>
<td>6/14/2020: Moses sent an email request for feedback on PSE testing criteria to all Data Submitters with a due date of 7/13/2020. Once all feedback is completed, it will be discussed at a future powerflow focus group meeting.</td>
<td>Staff: Moses</td>
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<tr>
<td>Item</td>
<td>Action Item</td>
<td>Date Originated</td>
<td>Status</td>
<td>Comments/Updates</td>
<td>Owner</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------------------------------------</td>
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<td>---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
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<tr>
<td>91</td>
<td>Manual task force to review the data coordination language and bring back to the MDWG if still warranted.</td>
<td>June 3, 2020</td>
<td>In Progress</td>
<td>6/4/2020: Manual Task force discussed this language again but without consensus. Discussions will continue on this.</td>
<td>Staff: Michael &amp; MDWG Manual Task Force</td>
</tr>
<tr>
<td>92</td>
<td>SPP Staff to determine the appropriate level of stakeholder review for models, especially models whose data is altered from original member submissions.</td>
<td>June 11, 2020</td>
<td>In Progress</td>
<td>Staff to meet and discuss options. Could be part of the model reduction effort recommendation if needed.</td>
<td>Staff: Michael, Moses, Sunny, David, Charlton</td>
</tr>
<tr>
<td>93</td>
<td>SPP Staff to review if year 9–11 model can be combined to reduce models</td>
<td>June 11, 2020</td>
<td>In Progress</td>
<td>Address with internal model reduction strike team</td>
<td>Staff: Michael, Moses, Sunny</td>
</tr>
<tr>
<td>94</td>
<td>SPP Staff to add owner number/name and a tab to the report card for letter of notice</td>
<td>June 11, 2020</td>
<td>In Progress</td>
<td>Added areas to the latest version. Revisiting to determine if additional items are needed</td>
<td>Staff: Kim</td>
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</tbody>
</table>
## REVISION HISTORY

<table>
<thead>
<tr>
<th>DATE OR VERSION NUMBER</th>
<th>AUTHOR</th>
<th>CHANGE DESCRIPTION</th>
<th>MODEL BUILD APPLICABILITY</th>
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<tr>
<td>21JUN18</td>
<td>SPP Engineering Modeling</td>
<td>Updated format</td>
<td></td>
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<tr>
<td>2018 v1.1</td>
<td>SPP Engineering Modeling</td>
<td>Modified Bus Naming and Map / Model request information</td>
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<tr>
<td>2018 v1.2</td>
<td>SPP Engineering Modeling</td>
<td>Updated Introduction &amp; Dynamic modeling section</td>
<td></td>
</tr>
<tr>
<td>2018 v2.0</td>
<td>SPP Engineering Modeling</td>
<td>Restructured the MDWG Procedure Manual</td>
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<tr>
<td>2018 v2.1</td>
<td>SPP Engineering Modeling</td>
<td>Updated the On-Peak &amp; Off-Peak model designations</td>
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<tr>
<td>2019 v2.2</td>
<td>SPP Engineering Modeling</td>
<td>Updated the MOD-032-1 Attachment 1 links</td>
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</tr>
<tr>
<td>2019 v2.3</td>
<td>SPP Engineering Modeling</td>
<td>Updated Station Service section and Shunt Device section</td>
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<tr>
<td>2019 v2.4</td>
<td>SPP Engineering Modeling</td>
<td>Updated Short Circuit and Dynamics sections</td>
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<tr>
<td>2019 v2.5</td>
<td>SPP Engineering Modeling</td>
<td>Updated the Transformer section</td>
<td></td>
</tr>
<tr>
<td>2019 v3.0</td>
<td>SPP Engineering Modeling</td>
<td>Updated Transformer section and general updates</td>
<td>2020 Series MDWG Model Build</td>
</tr>
<tr>
<td>2019 v3.1</td>
<td>SPP Engineering Modeling</td>
<td>Updated to remove duplicate Generator Data section and added clarification for renewable dispatch</td>
<td>2020 Series MDWG Model Build</td>
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<tr>
<td>2020 v4.0</td>
<td>SPP Engineering Modeling</td>
<td>Updated Aux Load, Shunt Data, ESR, DER data updates</td>
<td>2021 Series MDWG Model Build</td>
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<tr>
<td>Section</td>
<td>Page</td>
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<tr>
<td>Balancing and Transactions</td>
<td>44</td>
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</tr>
<tr>
<td>Substation Node-breaker modeling</td>
<td>51</td>
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<tr>
<td>Substation Numbering</td>
<td>52</td>
<td></td>
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<tr>
<td>Substation Naming Convention</td>
<td>53</td>
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<tr>
<td>Substation Physical Data</td>
<td>53</td>
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<tr>
<td>Substation Nodes</td>
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<tr>
<td>Substation Switching Devices</td>
<td>53</td>
<td></td>
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<tr>
<td><strong>MDWG model quality assurance</strong></td>
<td>55</td>
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<tr>
<td><strong>Section 4: Dynamic Data Requirements</strong></td>
<td>58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Procedure for Initialization and No-Disturbance Checks Of Library Dynamics Cases</td>
<td>60</td>
<td></td>
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</tr>
<tr>
<td>Dynamics Data Updates Using Excel Template</td>
<td>65</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complete Set of Dynamics Data</td>
<td>66</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Section 5: Short circuit Data Requirements</strong></td>
<td>67</td>
<td></td>
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</tr>
<tr>
<td>Mutual Impedance</td>
<td>67</td>
<td></td>
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<tr>
<td><strong>Section 6: Definitions</strong></td>
<td>70</td>
<td></td>
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<tr>
<td><strong>Section 7: Appendix I Master Tie Line File Data Fields</strong></td>
<td>72</td>
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</tr>
<tr>
<td><strong>Section 8: Appendix II Utilized Impedance Correction Tables</strong></td>
<td>80</td>
<td></td>
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</tr>
<tr>
<td><strong>Section 9: Appendix III Designating MOD-032-1 Data Submittal Assignment</strong></td>
<td>81</td>
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</tr>
<tr>
<td><strong>Section 10: Appendix IV SPP Model On Demand (MOD) Matrix</strong></td>
<td>83</td>
<td></td>
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</tr>
<tr>
<td><strong>Section 11: Appendix VII GMD/GIC Data Collection Template User’s Guide</strong></td>
<td>85</td>
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<tr>
<td>Geomagnetic disturbance modeling Data</td>
<td>85</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Section 12: Appendix V MOD-032-1 Attachment 1</strong></td>
<td>94</td>
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</tbody>
</table>
SECTION 1: INTRODUCTION

PURPOSE
This manual establishes consistent modeling data requirements and reporting procedures for the development of Near-term and Long-term Transmission Planning Horizon models necessary to support analysis of the capability, reliability, and suitability of the SPP Transmission System. This section describes the applicability of entities, Data Owners, equipment, and Data Submitters to which this manual is germane.

The latest modeling data requirements and reporting procedures for the Planning Coordinator’s planning area, the “SPP MDWG Model Development Procedure Manual” jointly developed with each of the PC’s Transmission Planners, can be found on the SPP corporate website, www.spp.org. Additionally, the schedule for submission of data and the list of MDWG models (case types/scenarios) can also be found on the SPP corporate website, www.spp.org. The schedule for model development will also be sent with the first data request.

The primary deliverable of the SPP MDWG is a set of base transmission system models (base cases) that include a reasonable projection of the anticipated transmission system conditions as will be operated by the SPP Transmission Operators (TOPs) in coordination with the SPP Reliability Coordinator (RC). The primary intent of these base cases is to provide SPP member Transmission Planners (TPs) and the SPP Planning Coordinator (PC) an effective starting point for reliability planning and compliance assessments. In addition, the base cases are developed in support of various SPP planning processes in accordance with SPP model data and reporting procedures that include maintenance and coordination of steady state, short circuit, dynamic, and geomagnetic disturbance models.

These base cases are a collection of transmission system data, as submitted annually to the SPP PC by applicable Data Submitters, meant to represent the transmission system in the SPP region in a steady-state, system-intact condition. The system topology, generator dispatch, and system loads modeled in the base cases are intended to be respective and representative of the projected transmission system as will be operated within the SPP footprint under reasonably anticipated weather and time-of-day conditions for the year and season being represented in each base case. Reasonable projections within each case include all firm generator commitments, forecasted load commitments, firm interchange commitments, expected transmission topology and expected seasonal transmission or generation outages. Additionally, base cases may include reasonable system projections based on details specified in later sections of this document and based on historical data or projected data.

SCOPE OF APPLICABILITY
It is well understood that transmission system modeling is a complex process predicated upon accurate and comprehensive data collection, review, and compilation. The SPP Model Development Working Group recognizes that to properly develop SPP Transmission System models, a constituency of responsible entities must collaborate in the model building effort. The transmission system subject to the SPP OATT including facilities 60kV and above must be accounted for in the SPP Transmission System models. Therefore, consistent with both the applicability of the NERC Data for
Power System Modeling and Analysis Reliability Standard (MOD-032-1)\(^1\), and the provisions of the SPP Open Access Transmission Tariff (OATT), as well as good utility practice, this manual is applicable to the following NERC-registered and non-NERC-registered entities:

- Planning Coordinator;
- Balancing Authority;
- Transmission Service Provider;
- Transmission Planners;
- Transmission Owners\(^2\) of equipment within the SPP Planning Coordinator planning area and/or of equipment that is part of the SPP Transmission System;
- Owners or lessors of generating units, including Generator Owners, within the SPP Planning Coordinator planning area of Network Resource(s) designated by the SPP OATT and/or who have submitted a Generation Interconnection Request consistent with the SPP OATT.
- Resource Planners;
- Distribution Providers;
- Network Customers receiving Network Integration Transmission Service pursuant to the SPP OATT for designated Network Load and/or having arranged Point-To-Point Transmission Service for non-designated load;
- Native Load Customers of an SPP Transmission Owner;
- Transmission Customers pursuant to the SPP OATT.

It is noted that within the SPP Region, consistent with SPP Regional Transmission Organization (RTO) procedures and the SPP OATT, SPP serves as both a Balancing Authority\(^3\) and Transmission Service Provider for the SPP Transmission System.

**Applicable Data Owners**

A subset of the applicable entities annotated above comprise the Data Owners subject to the modeling data requirements and reporting procedures of this manual:

- Balancing Authority is responsible for submitting modeling data for aggregated existing and future load, integrated resource plans, and interchange obligations corresponding to the case conditions specified.
- Transmission Service Provider is responsible for submitting modeling data for their existing and future service commitments and obligations corresponding to the case conditions specified.

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1 The NERC petition to remove the Load Serving Entity (LSE) registration was approved by 153 FERC ¶ 61,024, issued 15 October 2015. Therefore, the LSE registration is not discussed in this manual.

2 Capitalization is intended to include transmission-owning entities as defined in the NERC Glossary of Terms, as well as defined in the SPP OATT.

3 For Eastern Interconnection equipment only. WAPA-UGPR independently operates the WAUW BA area within the Western Interconnection for equipment which is under the SPP OATT.
• Distribution Providers are responsible for submitting modeling data for their aggregated existing and future load, and interchange obligations corresponding to the case conditions specified.

• Transmission Owners are responsible for submitting modeling data for their existing and future Transmission or sub-transmission equipment that they own or maintain.

• Owners or lessors of generating units, including Generator Owners, are responsible for submitting modeling data for the existing and future generating equipment that they own or maintain.

• Resource Planners are responsible for submitting modeling data for their existing and future long-term resource adequacy plan(s) of specific customer load demand and energy requirements, corresponding to the case conditions specified.

• Network Customers are responsible for submitting modeling data for their existing and forecasted load, existing and forecasted load transactions, as well as existing and forecasted resource transactions corresponding to the case conditions specified.

• Native Load Customers are responsible for submitting modeling data for their existing and forecasted load corresponding to the case conditions specified.

• Transmission Customers are responsible for submitting modeling data for their existing and forecasted transactions utilizing the SPP Transmission System, serving Network Load, or sales of Network Resources corresponding to the case conditions specified.

**Applicable Data Submitters**

The Data Owner shall be the Data Submitter, subject to the modeling data requirements and reporting procedures of this manual. A Data Submitter may be designated as the entity who takes responsibility for collating, formatting, and corresponding a Data Owner's modeling data to SPP, as Planning Coordinator, in the approved format. A Data Submitter may be delegated only if the following are completed:

1. Data Submitter is designated in writing, showing mutual agreement by the Data Owner and Data Submitter.
2. Written notification is provided to SPP, as Planning Coordinator, regarding the specific data (e.g., load at bus X; generating unit Y; transmission branch Z) for which the Data Submitter will be responsible for.

A completed Letter of Notice identifying responsibilities between a Data Owner and a Data Submitter is required to be submitted to SPP. A contractual agreement may be submitted in lieu of the Letter of Notice. This Letter of Notice is included in the appendix section. The Data Coordination Workbook shall also be completed to reflect responsibilities between Data Owners and Data Submitters, including documentation such as a Letter of Notice.

Responsibility for the timely and accurate submission of Data Owner information to SPP, as Planning Coordinator, resides with the Data Owner. When a Data Owner delegates the submission of data to a Data Submitter, all communication that would otherwise be sent to the Data Owner alone, will be

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4 When delegated, the Data Submitter is not responsible for validating data provided by the Data Owner.
copied to the Data Submitter.

A Data Owner’s submitted data shall not modify another Data Owner’s data without explicit consent. Data Owners are encouraged to coordinate data submissions that may impact another Data Owner’s system.
Applicable Equipment

The modeling data required from Data Owners supports both the creation of the Electric Reliability Organization ("ERO"), or its designee, Interconnection-wide modeling cases, and the other Near-term and Long-term Transmission Planning Horizon cases required under the SPP OATT\(^5\). Planned equipment, as differentiated from existing equipment, consists of equipment expected to be in-service for the case conditions specified (e.g., month; year). Existing or planned\(^6\) equipment for which non-equivalenced modeling data shall be reported include, but are not limited to:

1. All Facilities comprising the Bulk Electric System (BES).
2. All non-BES equipment 60 kV and above, subject to the SPP OATT\(^7\).
3. All BES or non-BES equipment that includes a normally-open point that, when closed, shifts load or creates a network path affecting the SPP Transmission System.
4. All non-BES equipment interconnecting within the SPP Transmission System or interconnecting the SPP Transmission System with non-SPP Transmission System(s), subject to the SPP OATT\(^8\).
5. All non-BES equipment known to have a significant interaction with the BES, including reactive resources.
6. All direct-current connections within the SPP region or interconnecting to Transmission outside of the SPP region.
7. All Network Resource generation assets, subject to the SPP OATT\(^9\), excluding Small Generating Facilities (< 2MW).
8. All Network Resource (pursuant to Item 7) generator step-up transformers and generator interconnection equipment. Generator interconnection equipment shall include, at a minimum, collector electrical equivalent representations, where applicable.
9. All Resources that are registered in the SPP Integrated Marketplace, including the transmission equipment necessary to delivery that Resource to the SPP Transmission System when the registered Resource is not directly connected to the SPP Transmission System.
10. All Network Load, subject to the SPP OATT\(^10\).
11. All firm power purchases served by SPP Network Resource(s) and firm power sales sunk to SPP Network Load, including all firm power transactions that result in an area interchange.

Other information regarding equipment not specified above may be requested by SPP, as the Planning Coordinator, or by Transmission Planner(s) for modeling purposes, as necessary. Likewise, consistent with MOD-032-1 Requirement R3, the Planning Coordinator or Transmission Planner may request additional data or clarification regarding technical concerns with modeling data submitted.

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5 Pursuant to the provisions of the OATT, equipment below the typical 100kV demarcation of the BES must be accounted for in the SPP Transmission System models.
6 As part of the MDWG model building process to support of the TPL-001-4 R1 model building requirement
7 Sixth Revised Volume No.1, Attachment AI, Part II-1.
8 Sixth Revised Volume No.1, Attachment AI, Part II-2.
9 Sixth Revised Volume No.1, Part III-30.
10 Sixth Revised Volume No.1, Part III-31
Written notification will typically be communicated through electronic means (e.g., email) to the Data Submitter and/or Data Owner and will include the technical concerns with the data submitted. Upon receipt of written notification, the Data Submitter and/or Data Owner shall respond to the notifying Transmission Planner or SPP, as the Planning Coordinator, with either updated data or an explanation with a technical basis for maintaining the current data in accordance with the reporting procedure schedule (“schedule”) jointly developed by the Transmission Planners and Planning Coordinator.

**Accountability**

SPP, through coordination with the MDWG, cannot be effective at building timely and accurate models without Applicable Entity participation. All Applicable Entities are responsible for providing the data necessary to model their Applicable Equipment. Likewise, Applicable Entities are accountable for meeting specific deadlines and milestones established by the MDWG, for model development, in the jointly developed schedule. The schedule will be made available to all Applicable Entities at the outset of each model-building period.

Clear and timely two-way communication between SPP, as Planning Coordinator, the Transmission Planners comprising the SPP PC, and Applicable Entities is vital to the successful compilation of modeling data, reporting, and ultimate production of accurate SPP Transmission System models. It is the responsibility of the Applicable Entity to communicate with SPP to establish the responsible contact for steady state, dynamic, and short circuit model data coordination.

Given that the MDWG relies upon Data Owner and Data Submitter input for the model building effort, the following are some of the established characteristics that support model-building best practices:

- Establishes a contact for model data coordination.
- Responds to model-building communications in a timely fashion.
- Data Owner begins coordinating data submittal well in advance of the initial model data submittal deadline.
- Submits model data ahead of established deadlines.
- Submit majority of model updates by initial model data submittal deadline.
- Ensures model data submitted is complete and accurate.
- Participates in MDWG conferences, calls and meetings.
- Performs a data integrity review of each model-building pass to identify and correct errors.
- Engages throughout the model-building process in a timely fashion.
- Keeps their respective managerial chain informed about model-building progress.
- Coordinates data submissions that may impact another Data Owner’s system.

Following each model-building cycle, SPP staff, in conjunction with MDWG members, will prepare a lessons-learned and modeling best practice recommendations assessment. This assessment will focus on challenges experienced by the preceding model-building cycle, attempt to identify root causes, and suggest improvements for subsequent model-building cycles.
MDWG experience has shown that some natural obstacles exist to achieving model-building best practices. The following cautionary situations are examples for the purpose of Data Owner and DataSubmitter awareness during the model-building process:

- **Appropriate lead times.** Data Owners may rely on other entities to provide data; therefore, Data Owners should consider lead times when requesting data from others (e.g., Data Owner entity X is the Market Participant and Network Load registrant who serves a municipal customer). Knowing that source data may be more difficult or slower to obtain, the Data Owner should act as early as possible so not to delay the submission of data until late in the model-building process.

- **An early and complete submission of a Data Owner’s modeling data does not eliminate the need for the Data Owner to participate in all model-building passes.** In many cases, model parameters that affect multiple Data Owners within a region (e.g., load, generation dispatch, and transactions) may change between model iterations. The aggregation of these changes can have a pronounced effect on the model data that Data Owners have submitted and emphasizes the need for checking/re-checking the integrity of a Data Owner’s model representations in each model iteration.

During each model iteration, an assessment of model-building progression and participation may be performed. Given that incomplete or late data submission has a tremendous impact upon the ability to meet the model-building schedule, any Data Owner who seeks to submit late data will be obligated to present before the MDWG about how proposed model changes will impact the models themselves, as well as impacts to the overall modeling schedule. The MDWG has the obligation to report its progress and achievement of model-building milestones to various SPP working groups/committees.

In cases where an Applicable Entity has not participated or otherwise supported MDWG efforts in good faith towards the achievement of published milestones, the MDWG may report non-participating entities to the TWG/MOPC.
SECTION 2: GENERAL INFORMATION

CONFIDENTIALITY AND PROPRIETORSHIP

The representation of future system elements in SPP data models is not an agreement to construct these elements when shown in the models or at any time. The configuration of each model system only reflects the necessary changes that the individual model system needs for maintaining reliable operation. The results of studies obtained through use of the data models developed by SPP will be the sole responsibility of the receiving party. The recipient of SPP data models must assure confidentiality and proprietorship.

SPP MDWG Steady-State, Dynamics, and Short Circuit Models are published according to the approved schedule.

MDWG CASE TYPE SET

The current MDWG Case Type Set can be found on SPP's website, spp.org, under the documents section of the Model Development Working Group.

STEADY-STATE AND SHORT CIRCUIT DATA FORMAT

PSS®E and MOD Users

The transmission modeling software approved by the SPP membership for performing planning and reliability studies is the Power Technologies Incorporated, Power System Simulator for Engineering (PSS®E) software. Data submitted for the building of the base SPP MDWG case types (models) needs to be in a format consistent with that used in PSS®E. The data shall be submitted via the SPP Models On Demand (MOD) Web Portal. Data submitted should be compatible with the MOD and PSS®E versions currently specified by SPP.

Non-PSS®E and Non-MOD Users

For those non-PSS®E users, load and generation profile data may be submitted via the Profile Submission form provided by SPP. SPP will aid with the submission of all other steady-state data in the correct PSS®E and MOD data formats. Any version changes will be discussed in the annual training provided by SPP.

The members are expected to contact the SPP Modeling Staff if there are any additional questions regarding the data format.

TYPICAL ANNUAL MODELS

<table>
<thead>
<tr>
<th>Season</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual Spring Peak</td>
<td>9 Annual + 1 Summer Peak</td>
</tr>
<tr>
<td>Annual Summer Shoulder</td>
<td>10 Annual + 1 Fall Peak</td>
</tr>
<tr>
<td>Annual Summer Peak</td>
<td>11 Annual + 1 Winter Peak</td>
</tr>
<tr>
<td>Annual Fall Peak</td>
<td>12 Annual + 2 Summer Peak</td>
</tr>
<tr>
<td>Annual Winter Peak</td>
<td>13 Annual + 2 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 April Minimum</td>
<td>14 Annual + 6 Summer Peak</td>
</tr>
<tr>
<td>Annual + 1 Spring Peak</td>
<td>15 Annual + 6 Winter Peak</td>
</tr>
<tr>
<td>Annual + 1 Summer Shoulder</td>
<td>16 Annual + 10 Summer Peak</td>
</tr>
</tbody>
</table>

The typical yearly models developed by the SPP MDWG, as identified within the NERC TPL reliability standards, encompass both near-term (years one through five) and longer-term (years...
six through ten) transmission planning models. The SPP models are defined in the Annual Models table above with those transmission planning models representing the near-term planning horizon consisting of the MDWG case types 1 through 13 and those representing the longer-term planning horizon consisting of the MDWG case types 14 through 16. The longer-term models may be incremented or additional models may be included as required to support ERAG MMWG.

The annual series of models are developed by SPP staff with input from the Model Development Working Group and the Transmission Working Group.

The schedule for submission of data and list of MDWG models [case types] can be found on the SPP corporate website, www.spp.org.

**DATA TRANSMITTAL**

Transmitting data to the Southwest Power Pool can be accomplished as follows:

1. **Electronic --- GlobalScape**
2. **E-MAIL --- SPPEngineeringModeling@spp.org**

The preferred method of submittal is through the “SPP MDWG File Sharing Site”, GlobalScape. Include a file (excel, word, or equivalent) with description of data files submitted and which to which models they apply.

The transmitted data file should include the title of the first case and area name, followed by the changes to the first case, title of the second case and the area name, followed by the changes to the second case, etc. Case title lines should include the case title as in the following format examples: *04SP, *04FA, *04SH, *07SP (no spaces between characters).

**SPP MODEL RELEASE GUIDELINES**

**Steady-State and Short Circuit Models**

SPP Base Case steady-state models and short circuit models are available to all SPP members. SPP and its members, by participating in SPP base case development, grant authority to the other participating members and SPP to release SPP Base Case steady-state models or reduced network equivalents of those models to government agencies. The public may receive models by filling out a SPP models order form and signing the appropriate SPP Confidentiality Agreement. For more information on requesting Base Case steady-state models, contact the SPP Model Contact.

Base case steady-state models of external systems, which are beyond the electrical borders of SPP and released under FERC Form 715 to government agencies, shall be the SPP models or a reduced network equivalent of the SPP models. If the external systems are equivalenced, such external models must be disclaimed, as equivalent representations not intended for study of the transmission systems in those external areas.
SPP Model Contact:
Please send all general modeling questions and concerns to SPPEngineeringModeling@spp.org.

Request an SPP Map / Model
You may request an SPP Transmission Map/Model through the Request Management System by clicking on the "Order Transmission Map/Model" quick pick option.

Questions? You may find it helpful to consult SPP Maps & Models FAQ.

Last Updated July 26, 2018

MMWG DELIVERABLES

REGIONAL COORDINATORS
The Regional Coordinators will provide the following to the MMWG Coordinator(s).
1. Steady-State Cases
   a. Data as needed to create the MMWG steady-state cases in RAWD or Saved Case format, regional representation shall be within an entire solved MMWG steady-state model in the proper PSS®E revision format
   b. Tieline and interchange data in the specified format
   c. IDEV files for any data changes
   d. PSS®E formatted contingency file containing five N-1 contingencies valid for all cases in the model series.
   e. Data Dictionary containing fields for Bus Number, 18 character PSS®E Bus Name, EIA Plant Code (U.S. only) and Non-Abbreviated Bus Name.
2. Dynamics Cases
   a. Dynamics input data in DYRE format for new models
   b. SDDB Excel worksheet for changes to the database
   c. FLECS code and documentation for user defined models
   d. Load conversion CONL file sorted by area
   e. List of netted generation buses
   f. Two contingency events per region in IDEV format

MMWG COORDINATOR(S)
The MMWG Coordinator(s) will post the following to the ERAG Web Site.
1. Steady-State Cases
   Initialized steady state and regional contingency cases.
   a. Steady-State RAWD case file
   b. Conversion IDEV files
2. Dynamics Cases
   Dynamics case input data, output files and instructions including:
   a. Dynamics input data in DYRE format
   b. FLECS code for user defined models
   c. Load conversion CONL file sorted by area
   d. Any IPLAN or PYTHON programs necessary to set up the dynamics case
4. Final reports

System Abbreviations & Area Number Assignments
System Abbreviations & Area Number Assignments can be found on SPP’s website, spp.org, under the documents section of the Model Development Working Group.
MDWG Contact List
The MDWG Contact List can be found on SPP’s GlobalScape under Modeling (CEII, RSD) → SPP Modeling Contacts → 3. Final Modeling Contacts

**NOTE** – A complete listing of other SPP acronyms can be found on the SPP website at SPP Glossary

Compliance

1. MDWG Model Development Procedure Manual
   Note: The latest document can be found on SPP.org

2. MDWG Power flow, Short Circuit, and Dynamic model schedule and list
   Note: The latest document can be found on SPP.org

3. Data Submittal Forms (This is a separate document)
   Note: The latest document is posted with every model set

4. MDWG Procedure for late or no data submittal (FUTURE)
SECTION 3: STEADY-STATE DATA REQUIREMENTS

Steady-State models are developed for an annual series of SPP and ERAG MMWG cases. Specific models are prepared and modified for use in SPP designated studies as required by the OATT and Planning Criteria. In order to establish consistent Steady-State models which represent the planning horizon necessary to support analysis of the reliability of the interconnected transmission system, the following Steady-State modeling requirements. Dynamic and Short-Circuit models are derived from the Steady-State models.

The Steady-State models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Non-topological modeling updates that are season specific can be made by submitting Profiles to MOD.

ENGINEERING DATA SUBMISSION TOOL

MOD data should be kept current for each pass during the MDWG model build. The EDST contains informational data as well as modeling data that Data Submitter shall keep current for each pass of the MDWG model build.

1. Transactions – Firm and non-firm reservations with other entities that shall be coordinated before submission to SPP (Reference appendix VIII for more information).
2. Generators – Required generator data that is not otherwise captured in the models including but not limited to the generator type, long name, and associated Auxiliary load.
3. SPP Modeling Assignments – Contains PSS®E modeling area, owner, zone, and bus range information pertinent to SPP.
4. Load Details – Identify loads not served by native model areas.
5. Bus Details – List of all buses in the models that includes long names, voltage level, area, owner, and EIA plant codes.
6. Interregional Ties – PC to PC branch and transformer ties that shall be coordinated before submission to SPP.
7. Outages – Outages known during the annual model building process for buses, generators, branches, transformers, and shunts that meet TPL-001 requirements shall be modeled. Data Submitters are responsible for annotating known outages to be modeled within the EDST, as well as ensuring that the known outages are correctly modeled in the appropriate season(s) when the known outage is scheduled. MOD projects shall be submitted with effective dates corresponding to the scheduled period of the known outages.
**Table 1: Season Date Range and Cutoff Dates**

<table>
<thead>
<tr>
<th>Season</th>
<th>Date Range</th>
<th>Cutoff (On or Before)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Light</td>
<td>April 1 – May 31</td>
<td>May 1</td>
</tr>
<tr>
<td>Summer</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Summer Shoulder</td>
<td>June 1 – September 30</td>
<td>August 1</td>
</tr>
<tr>
<td>Fall</td>
<td>October 1 – November 30</td>
<td>November 1</td>
</tr>
<tr>
<td>Winter</td>
<td>December 1 – March 31</td>
<td>February 1 (yyyy+1)*</td>
</tr>
</tbody>
</table>

*Example of 2017 Winter: 12/1/2017 – 3/31/2018; yyyy = 2017, yyyy+1 = 2018

**LOAD FORECAST**

Load forecasting methodologies vary throughout the electric industry. SPP depends on load forecasts from Data Submitters to apply to the planning models. These load forecast amounts are to be not Coincident to the SPP region, meaning that the hour that a Data Submitter’s system experiences a peak demand for a particular season, might not be the same hour that SPP, as a region, experiences a peak demand. In order to bring consistency and equivalency to the load forecast data submitted to SPP, load forecast data shall be based on a 50/50 forecast.

A 50/50 load forecast relates to a forecasted load amount having an equal probability of being either higher or lower than the amount forecasted. The forecasted load value is at the 50th percentile of a normal or similarly shaped distribution curve and is typically discussed in terms of exceedance such that there is a 50% probability that the load forecast will be exceeded due to abnormal weather.

Some loads within the planning models are non-conforming and should not be scaled (e.g. arc furnace, irrigation load that is either on or off). These loads should be modeled as non-scalable in PSS®E.

Some studies may require load forecasts other than a 50/50 load forecast and may be requested for such special studies. For example, a 90/10 load forecast has a 10% probability that the load forecast will be exceeded, which means the load forecast amount is higher than a 50/50 load forecast amount and would be considered atypical for general SPP transmission planning purposes.

There are various methods used to develop such forecasts and the forecasts are dependent upon many factors such as historical load values, temperature, humidity, economic forecasts, time of day, day of week, holidays, special events, and load uncertainty. Other factors, some of which are controllable, also impact the amount of forecasted load. Controllable Demand Side Management (DSM) and Distributed Energy Resources (DERs) are such factors.

Load forecasts shall not be reduced for application of controllable DSM. There is control over whether or not the load will be shed by an operator or end-user and therefore cannot be guaranteed that the load will be reduced during peak hours. Load forecasts should be reduced for application of non-controllable DSM. This load has a high probability of being shed during peak hours without manual intervention. For purposes of transmission planning, it is recommended that Distributed Energy Resources should not be applied to a Data Submitter’s load forecast amount for incorporation into the SPP planning models.

When it becomes necessary or desirable to make changes in delivery point facilities, to upgrade, retire, replace or establish a new delivery point, including metering or other facilities at such
location, the provisions set forth in Attachment AQ of the OATT shall apply. Loads that have completed the Attachment AQ process or any other applicable SPP process, and have an updated service agreement, or are in the process of finalizing a service agreement, if applicable, should be included in the Data Submitter’s load forecast by the load submittal deadline in the MDWG model build schedule. SPP may reject any MOD projects or PSS® idevs that attempt to add, delete or modify delivery points that have not been studied either through the Attachment AQ or any other applicable SPP process. Data Submitters are required to assign the appropriate type and status to load projects in MOD.

Summary of Data Submitter’s load forecast data comprisal:

1. Not Coincident to the SPP region
2. 50/50 load forecast
3. Load forecast amount includes non-controllable Demand Side Management
4. Load forecast amount excludes controllable Demand Side Management
5. Load forecast amount excludes Distributed Energy Resources (recommended)

**ON-PEAK/OFF-PEAK MODELS**

Seasonal peak models developed by SPP include: Summer On-Peak, Winter On-Peak, Spring On-Peak, and Fall On-Peak. These four seasonal models are built to represent the expected coincident seasonal peak based on each Data Owner/Data Submitter system peak load. Data Owner/Data Submitter peak load may not be coincident to the SPP Balancing Authority Coincident Peak.

In addition to the seasonal On-Peak models, SPP develops two Off-Peak models, which are Spring Light Load and Summer Shoulder models.

The Light Load model is developed with the intent to capture a Data Owner/Data Submitter system minimum load during the spring timeframe.

The Summer Shoulder Off-Peak model is typically defined to be 70% - 80% of the total Summer On-Peak load level confined within each of the individual Data Owner/Data Submitter’s transmission system. The Summer Shoulder Off-Peak loading is representative of the average of the anticipated summer season daily peak hours, but is not a seasonal Summer Peak representation.

<table>
<thead>
<tr>
<th>Model</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spring On-Peak (G)</td>
<td>April 1&lt;sup&gt;st&lt;/sup&gt; through May 31&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>Summer On-Peak (S)</td>
<td>June 1&lt;sup&gt;st&lt;/sup&gt; through September 30&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Fall On-Peak (F)</td>
<td>October 1&lt;sup&gt;st&lt;/sup&gt; through November 30&lt;sup&gt;th&lt;/sup&gt;</td>
</tr>
<tr>
<td>Winter On-Peak (W)</td>
<td>December 1&lt;sup&gt;st&lt;/sup&gt; through March 31&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>Spring Light Load Off-Peak (L)</td>
<td>April 1&lt;sup&gt;st&lt;/sup&gt; through May 31&lt;sup&gt;st&lt;/sup&gt;</td>
</tr>
<tr>
<td>Summer Shoulder Off-Peak (SH)</td>
<td>June 1&lt;sup&gt;st&lt;/sup&gt; through September 30&lt;sup&gt;th&lt;/sup&gt; Typically 70% - 80% of Summer On-Peak load level</td>
</tr>
</tbody>
</table>

Data Owners of load that is pseudo-tied into SPP shall submit load forecasts to both SPP and the entity in which the load is embedded. Owners of load that is pseudo-tied out of SPP should submit load forecasts to the entity in which the load is embedded.

External load is load not affiliated with load forecasts submitted by SPP Data Submitters to SPP for planning model building purposes.
LOAD DATA
Load data is maintained in MOD via a profile file which is applied to the model. Profiles,Loads can belong to an Area that is not the same as the Bus Area. The default solution technique will solve the case with Tie Lines and Loads. The Tie Lines and Loads solution option assumes that the Loads Area generation serves the load.

The non-scalable Loads will be identified in the non-scalable Load worksheet of the EDST. This allows model builders to modify models without changing the loads that are constant.

Loads that are owned by municipal utilities should be modeled with an identifier in front of the number (i.e. Rayburn County load one should have the ID “R1”). These loads should be maintained in the Load Mapping worksheet of the EDST.

AREA SUMMARY REPORT
The Area Summary Report is an important part of data preparation and should be the initial step of the update process. This report, though not part of the steady-state input forms, is an important part of the data coordination process. As such, the report should be distributed to all appropriate systems at least one week before the initial update data is due at the SPP Office. The standard area abbreviations should be used on the area summary report and in the steady-state input data of area interchange and transactions. The following sequence of steps is to be used in completing this report:

1. The system name and area number, along with the name and phone number of the person that prepared the report, should be entered at the top of the form in the appropriate location.
2. The area slack bus and bus number. The area slack bus is to adjust for individual system losses only. It is not necessary for the area slack bus to be used for area load control in actual operation. Generation dispatch should be made to prevent the area slack bus from going to negative power output or power output above the stated rating of the unit when accounting for area losses. It is best that the area slack bus not represent a base load unit. The estimated slack bus generation should also be entered (Item 7). There should be room left on the slack bus for generation movement up & down.
3. For consistency, it is important that each system continue using a particular area slack bus rather than choosing a different bus from year-to-year, unless a specific reason exists to justify such a change. There is a new row on the Area Summary Sheet to identify the slack bus. To aid in solution time of the cases, the area slack bus should be located on a relatively strong portion of the system.
4. Use of a renewable resource should be avoided unless there are no other resources to designate as the area slack. If a renewable resource must be used then approval must be given by the MDWG.
5. An entity's area slack machine shall be modeled within the entity's model area.
6. In the case where a model area has no slack machine designated or in-service, an imbalance situation could occur and the imbalance will go to the system swing machine leading to an undesirable state. Load plus losses, generation, and transactions must balance in the model area without a slack machine.
7. The case year and season should be entered in the appropriate locations in chronological order.
8. The current system official load forecast should be entered as net load (Item 6).
9. The estimated losses should be entered (Item 5). The reference cases can be used as a starting point to estimate system losses.
10. Load equals net load minus estimated losses (Item 4).
11. Purchases and sales should be entered (Item 2). These values must be coordinated with the parties involved in the interchange transaction prior to data preparation. The algebraic sum of these transactions should be equal to the total area interchange.
12. Net power (Item 3) must equal net load (Item 6). Generation (Item 1) is equal to the net power plus interchange.

**TIE LINE COORDINATION**
Each SPP system will receive a tie-line data comparison summary for the initial base case and after the final models are published. The member must coordinate with its neighbors on the tie line representation in the models being developed. This coordination should consist of:

1. Agreement on which bus is to be metered for area loss accounting,
2. The in-service and out-of-service dates, if applicable,
3. Tie line characteristics and ratings
4. System responsible for supplying the update data.

SPP Member tie data (Intra-SPP) is maintained in a MOD Project file. The majority owner of the tie is responsible for maintaining the tie’s steady-state, sequence, and ratings data.

SPP tie data with external entities (Inter-PC) is maintained in the MMWG PC tie line list. Entities must submit changes using the latest list, which will be posted with the latest case set. Changes are to be highlighted in order for SPP Staff to easily discern the submitted changes. The file name shall contain the company name of which is submitting the change. There will be other lower voltage SPP ties which are not listed in the NERC list. They will be checked using the SPP tie line reports.

**LINE AND TRANSFORMER DATA**
Additions to the system tend to move from year-to-year based on changing load growth forecasts and budget requirements. As a result, future lines and transformers may move through several future cases. Line and Transformer Data is contained in MOD Projects and phases. The Project Type, Status, and Phase Effective Date determine if the data will be included in a particular model.

The following steps should be considered when preparing line and transformer data:

1. The device code (Bus, Branch, Transformer) specifies what data is being added to the base case. The action code (Add, Modify, Delete) specifies the action to be taken with the Project data. Specifying the deletion of a bus will require a similar record to delete all associated or connected devices with the bus (lines, generators, loads, transformers, etc.) from the base case.

2. The “from bus,” “to bus”, and circuit number identify the line or transformer. The order in which bus numbers are entered is important for tie lines to identify which bus is metered for loss accounting in some data formats. The “from bus” is assumed to be the metered end (unless the “to bus” is entered with a negative) and the “to bus” area will collect loss responsibility. For transformers, this order is also important in all formats because it specifies to which bus the Load Tap Changer (LTC) will attempt to maintain voltage and/or which bus is tapped. The code U in the branch data allows the user to select proper metered and tapped side by always entering the tapped side as the “from bus” or first bus number after the change code.
The “from bus” is the metered end unless the “to bus” or second bus number is a negative number. Remember to include the circuit identifier.

3. The positive, zero, and negative sequence branch impedance parameters shall be provided on a 100 MVA base (per unit value). The smallest allowable reactance is 0.00011 P.U. on a 100 MVA base. Reactance values less than minimum will cause the steady-state program to treat the line as a zero impedance line to reduce solution time.

4. The positive, zero, and negative sequence line charging data (conductance and susceptance) shall be provided on a 100 MVA base (per unit value) as applicable. A default value of zero will be assumed if no data is provided. Line charging data will be provided in the appropriate units depending on the specific format being utilized. Accuracy is needed to ensure a proper voltage profile in the model.

5. Each Data Submitter shall submit normal and emergency ratings for each branch (AC Transmission Line or Circuit, two-winding, and three-winding transformer). Each branch must have a specified Rate 1(normal, continuous) and Rate 2(emergency) entered in the first two fields (RATE1 and RATE2, respectively) for each seasonal model; use of the third rating field (RATE3) is optional.

6. Circuit mileage should be entered in the appropriate line length field of branch data. Ownership data for the line should also be entered in the appropriate fields of branch data. This mileage and ownership data will be used to validate and calculate Megawatt-mile for the OATT. Circuit mileages should be coordinated on all jointly owned lines. Invalid line lengths result in inaccurate revenue allocations.

7. All NERC flowgates must be included in the data submitted by each region to the MMWG such that those flowgates are not equivalenced in the steady-state models. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer. Enough detail should be added to model the flowgate accurately.

**BUS DATA**

For all SPP steady-state models, systems will model buses within their SPP allocated bus range. For the sake of consistency, the bus names and numbers should remain constant from case to case and year to year. When a change in bus voltage occurs, a new bus number will be given to the new higher voltage bus. This enables SPP to track when the old bus voltage changes. All interregional tie bus names should conform to the entries in the Master Tie Line Database as approved by the Regional MMWG Coordinators. All tie line bus names and numbers should be standard and unique within each area in all models in a case series. Changes in tie line bus names and numbers from one series to the next must be kept to a minimum to reduce changes in computer support programs. Unique generator bus names, base voltages, and unit id combinations should be consistent from case to case within a model series. This will help ensure that the SPP bus names do not conflict with ERAG MMWG Standards.

The following steps describe options and data for most bus data formats:
1. The device code and the change code determine describes what action(s) are taken with the data supplied (addition, deletion, modification, etc...).

**NOTE:** When a bus is deleted or removed from service, all associated network devices (lines, transformers, loads, generators, etc.) must also be deleted or connected to a different bus in the applicable model(s).

Although voltage codes have no uniform association with voltage classes, historical consistency is encouraged amongst entities within a highly integrated network. Bus names can have up to 12 characters with the first character, preferably, alphabetic rather than numeric. The name should be left justified. Characters which can aid in filtering or association are allowed excluding the following characters: commas, asterisks, single quotes and double quotes. The last character field of the bus name should be the SPP voltage code described as follows. The historical SPP voltage code list shown below is recommended, but not required:

<table>
<thead>
<tr>
<th>Voltage Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - Below 69 kV</td>
<td>4 - 138 kV</td>
</tr>
<tr>
<td>2 - 69 kV</td>
<td>5 - 161 kV</td>
</tr>
<tr>
<td>3 - 115 kV</td>
<td>6 - 230 kV</td>
</tr>
<tr>
<td>7 - 345 kV</td>
<td>8 - 500 kV</td>
</tr>
<tr>
<td>9 - 765 kV or above</td>
<td></td>
</tr>
</tbody>
</table>

1. For generator regulated buses, a desired voltage set point will be given. Generator buses should be modeled with operating characteristics as close to actual as possible. Generator ratings should also be specified for each generation bus (whether on or off-line) as described in SPP Planning Criteria Section 7.1. Generators shall model the gross output of the generating facility and explicitly model the Station Service or Auxiliary load. The practice of using generator for voltage support only (i.e. no real power output), should be avoided unless a synchronous condenser or static var controller physically exists on that bus or nearby in the system. When a generator is modeled offline (status 0), the MW (PGEN) and MVAR (QGEN) fields should be zeroed. Regulating transformers should not be located at a bus with a controlling generator or regulating shunt device.

2. Bus loads should be specified with the real and reactive power values provided as a pair in all entries. The load should be modeled to reflect the expected in-service/out-of-service status.

3. When scaling area load, it is important to consider the reactive power as well as real power. This is particularly true when referencing a case of a different season. Realistic reactive load representation has a major effect on the overall case voltages. Reactive requirements are different for the various season models.

4. Capacitors, reactors, and SVCs represented in the models should be consistent with actual seasonal operation. These devices should be used in future cases calling for local area voltage support, rather than falsely regulating a bus. Attention should be given to these installations in cases that are referencing a different season model. Tertiary reactors should be modeled on the low voltage bus of transformers if the tertiary is not modeled explicitly.
**SHUNT DATA**

Shunt reactive devices are key components used, in conjunction with generating unit excitation, to regulate transmission system voltage, as well as facilitate operating flexibility while assisting to maximize transmission capacity. Shunt reactive devices are typically characterized as either static or dynamic, based upon their responsiveness to system voltage variations.

Static reactive devices tend to respond more slowly, either through automatic or manual switching according to a broader voltage schedule or range of system voltage conditions. Dynamic reactive devices tend to respond very quickly, automatically adjusting their reactive contributions to the system so as to maintain a voltage set point (Regulating device). The four primary static and dynamic reactive device categories are:

- **Fixed shunt device (Locally-switchable static devices)** - Typically require a switchman to physically close a switch in the field under de-energized conditions. These devices require human interaction at the location of the device in order to change the status and are not self-switching. These devices should be represented as fixed shunt devices in software simulations.

- **Switched Shunt, Locked mode (Remotely-switchable static devices)** – Can be placed in, or taken out of, service by a System Operator remotely operating a switch from a Control Center. These devices require human interaction in order to change the status, are not self-switching, are not used for automatic system adjustments, but are used for manual system adjustments (regulating device). These devices should be represented as switched shunt devices in locked mode (0) in software simulations and set to their expected seasonal Mvar (Binit) values.

- **Switched Shunt, Discrete mode (Automatically-switchable static devices)** – Can be placed in, or taken out of, service by an automatic controller (e.g., the Protection System) that actuate powered switch closure. These devices are self-switching, are used for automatic system adjustments (regulating device), but not used for manual system adjustments. These devices should be represented as switched shunt devices in a discrete switching mode (1, 3, 4, 5, or 6) in software simulations.

- **Switched Shunt, Continuous mode (Automatically-switchable dynamic devices)** – Reactive contribution is adjusted by an automatic controller. These devices are used for automatic system adjustments (regulating device), but not used for manual system adjustments. Examples of dynamic reactive devices include: static VAR compensators (SVC), static compensators (STATCOM), and direct current voltage source converters (VSC). These devices should be represented as switched shunt devices in a continuous switching mode (2) in software simulations.

Load flow software offers multiple options for modeling shunt reactive devices and care must be used when selecting the appropriate representation. The primary modeling capability considerations for non-rotating mass reactive devices are:
• Shunt implementation: fixed, or switched.
• Simulated control mode: Locked, discrete, or continuous.
• Regulated voltage band limits: high \( V_{hi} \) and low \( V_{lo} \).

Upon selecting the appropriate modeling representation for the non-rotating mass shunt reactive device, the Data Owners/Data Submitter shall ensure that the following is entered for:

*Non-regulating shunt capacitor or reactor device (static, locally-switchable device)*

- Fixed shunt (no control mode) with a unique shunt ID.
- Total reactive device admittance\(^{11}\) (MW and MVAR) that represents the aggregated contribution of the reactive banks or blocks installed as a fixed device.
- In-service status, set to zero (0) if the device is not in-service.

*Regulating shunt devices*

- Switched shunt with 'SW' shunt ID (forced by software).
- Total reactive device admittance\(^{12}\) (MVAR only), differentiated into quantities of admittance that represent the installed controllable device reactive banks or blocks, as appropriate.
- Regulated voltage band limits, either as a schedule \( V_{hi} \neq V_{lo} \) for static reactive devices or as a set point \( V_{hi} = V_{lo} \) for dynamic reactive devices, appropriate to the equipment.
- Reactive limits, for dynamic reactive devices only.
- Control mode-of-operation, as listed above:
  - Static, remotely-switchable device – locked, control mode (0).
  - Static, automatically-switchable device - unlocked, discrete control modes (1, 3, 4, 5, or 6).
  - Dynamic device – unlocked, continuous control mode (2).
- Assignment of the regulated bus, for switched shunt representations only.
- In-service status, set to zero (0) if the device is not in-service.

The Data Owners/Data Submitter should consider the load flow numerical solution stability implications of the regulated voltage band limits \( (V_{hi}, V_{lo}) \) when entering data for the shunt reactive devices. The ability of the load flow numerical solver to derive an acceptable voltage state may be impeded by a switched shunt with a discrete control mode whose reactive contribution, when switched, pushes the voltage of its connected bus outside of convergence tolerances. Therefore, a limit difference of less than 0.025 pu shall not be used when entering the regulated voltage band limits \( (V_{hi}, V_{lo}) \) for a switched shunt reactive device. Similarly, switched shunts shall not be connected to generator buses or to a generator bus through a zero-impedance branch.

All shunt reactive devices attached at transmission-level buses (i.e., 60 kV or greater) or attached to the tertiary of a transmission-level power transformer shall be modeled explicitly and not as loads or aggregated with loads. Further, static reactive devices connected to transmission lines are known as line shunts. The PSS®E load flow software allows line shunts to be modeled as part of the BRANCH

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11 Shunt conductance and susceptance quantities are entered in units of MW and MVAR representing the total per-unit admittance at rated voltage, on system base MVA.

12 Shunt susceptance quantities (conductance is assumed to be zero) are entered in units of MVAR representing the total per-unit admittance at rated voltage, on system base MVA.
data record. An alternative approach is to model the line shunt explicitly by using an intermediate bus and zero-impedance branch (ZBR), as shown in Figure 1, even when the line shunt is locally-switchable only and expected to match the in-service status of the connected branch. In this scenario, losing the transmission line, but not the line shunt, can cause low voltage conditions that may not be realistic.

![Figure 1. Example depiction of line reactor modeling.](image)

The Data Owner/Data Submitter must remember that the switched shunt reactive device control mode employed by the load flow software offers significantly more flexibility than shunt reactive devices implemented in the transmission system. Care should be taken to best represent the actual operation of installed shunt reactive devices and not allow unlocked control modes when inappropriate. During the model build process, similar to the process of case conditioning prior to analysis, remotely-switchable devices may be unlocked and automatically-switchable devices may be locked, expressly for the purpose of obtaining a converged load flow solution. However, care must be taken to ensure that the final state of the model contains the correct control mode, including locking, appropriate to the shunt reactive devices represented. The Data Owners/Data Submitters should also consider individual device protection settings as they relate to voltage...
control mode and limits.

**GENERATOR DATA**

Generating unit MW and MVAR output shall be submitted such that the unit is within the PMAX, PMIN, QMAX, QMIN and MVA base limits with consideration of MOD-025-2 and SPP Planning Criteria 7.1.1., or company-specific procedure for testing the gross capability of the generator. Generator real power capability shall be set to the gross maximum and minimum values (PMAX and PMIN) with Auxiliary load modeled explicitly. Reactive power capability maximum and minimum values (QMAX and QMIN) in the models should be based on unit test data at real power capabilities.

For steady state analysis, the synchronous impedance of a generating unit is not used in load flow calculations. However, the representation for complex machine impedance for the generating unit, called ZSOURCE (alternatively known as ZSORCE) is composed of components ZR + j ZX, and is a critical parameter in performing switching studies, fault analysis, and dynamic simulations. ZSOURCE shall be calculated based upon the Machine MVA Base (MBASE). The Data Owner shall ensure that accurate and appropriate ZSOURCE data (ZR and ZX) are entered into the Machine Data Record according to XSOURCE Table.

For dynamic simulation, this complex impedance must be set equal to the unsaturated subtransient impedance for those generators modeled by subtransient level machine models, and to transient impedance for those modeled by classical or transient level models. Machine MVA Base (MBASE) and Machine Impedance (ZSOURCE, ZR + j ZX) values for the steady-state models must match dynamic data and should be established through manufacturer data or generator testing. Future Generators that are in the models but are not budgeted for construction need to be identified in the Generator Data worksheet of the EDST.

Energy storage (pumped hydro, battery, flywheel, etc.) shall be modeled with the generator rated capabilities and a dispatch amount (Pgen) no greater than the rated output that can be sustained continuously for a minimum of one (1) hour.

For synchronous machines, the short circuit model should be comprised of saturated transient and subtransient impedance data. The Data Owner shall ensure accurate and appropriate saturated transient, subtransient, positive sequence, negative sequence, zero sequence, and (if applicable) grounding impedance data. This data shall be entered into the generator Sequence Impedance Data Record. In some cases, resistances for units may be assumed negligible, as long as reactance information is provided.

When modeling mothballed and future retired units, the unit will be modeled offline (in-service status = 0). The capability amounts for PMAX, PMIN, QMAX, and QMIN should not be changed until the unit is fully decommissioned) similar to units that are not dispatched in the particular seasonal model. Unit retirement information will be provided in a separate document and posted through a secure website. Decommissioned units should be removed from the models.

**Modeling Process for Generator Parameters**

a. The Generator parameter P_{MAX} shall be modeled as a gross seasonal maximum capability based on SPP Planning Criteria 7.1 testing and reporting procedures and in consideration of MOD-025-2, or company-specific procedure for testing the gross capability for the generator.
b. Generating plant Station Service load and Auxiliary loads shall be represented in normal plant configuration, corresponding to the load appropriate to operation of the generating plant. All Station Service load and Auxiliary load representations shall:
   
i. Be modeled explicitly on the appropriate bus, corresponding to the voltage to which the Auxiliary load is served. Model representations of Auxiliary load connected to the generating unit bus (Figure VII-1), Auxiliary load modeled with separate transformation (Figure VII-2), and Auxiliary load modeled on the high-side bus of the station service transformer (Figure VII-3) are acceptable.
   
   ii. Be annotated as non-scalable.

   Figure VII-1. Common bus representation

   Figure VII-2. Separate transformation representation

   Figure VII-3. Transformer high-side representation

c. Experience has shown that generating plant Station Service load and Auxiliary load may vary considerably based upon generating plant dispatch and operating conditions. Therefore, generating plant Station Service load and Auxiliary load may be modeled as aggregated or non-aggregated generating plant load, representing the total quantity of fixed and variable Station Service load and Auxiliary load.

   If generating plant Station Service load and Auxiliary load is **aggregated**, the total load quantity shall properly reflect the total real and reactive loading for the generating units. The aggregated generating plant Station Service load and Auxiliary load shall use “Sn” in the Load ID for one or more aggregated generating plant Station Service loads (Figure VII-4a).

   If generating plant Station Service load and Auxiliary load is **not aggregated**, each load quantity shall properly reflect the real and reactive loading expected during the corresponding dispatch (e.g., generating plant Pgen may be less than Pmax) and operating conditions for the generating units. Combined loads are analogous to aggregating generating plant Station Service load and Auxiliary load, with additional detail specifying the fixed and variable portions of total generating plant load (Figure VII-4b).

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13 Station Service load and Auxiliary load shall not be netted against generating plant dispatch by reducing the Pgen of a unit with an amount corresponding to the plant Auxiliary load.
VII-4b). The combined or discrete (Figure VII-4b and Figure VII-4c) load representations shall:

i. Use “F

" in the Load ID field14 to designate fixed load quantities that do not vary with plant dispatch.

ii. Use “V

" in the Load ID field14 to designate variable load quantities that do vary with plant dispatch.

![Diagram of load representations]

**Figure VII-4. Examples of generating plant Auxiliary load representations (aggregated, combined, and discrete).**

**Only generating plant Station Service load or Auxiliary load IDs should be labeled with “S

”, “F

”, or “V

”; all other load types should be labeled differently.**

Station Service or Auxiliary load modeling should be done in accordance with the state of the generator as follows:

<table>
<thead>
<tr>
<th>Generator State</th>
<th>Aggregated “Sn” SS or Aux Load</th>
<th>Variable “Vn” SS or Aux Load</th>
<th>Fixed “Fn” SS or Aux Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Online</td>
<td>In-Service</td>
<td>In-Service</td>
<td>In-Service</td>
</tr>
<tr>
<td>Offline</td>
<td>In-Service</td>
<td>Offline</td>
<td>In-Service</td>
</tr>
<tr>
<td>Decommissioned</td>
<td>Removed from model</td>
<td>Removed from model</td>
<td>Removed from model</td>
</tr>
</tbody>
</table>

Aggregated Station Service or Auxiliary loads shall be updated to reflect the dispatch of the associated generator.

**Modeling of Wind/Solar Renewable Resources \(P_{\text{GEN}}\)**

- Spring Light Load Off-Peak models: Output of renewable resources with long-term firm transmission service will be modeled in the light load model at each facility’s latest five-year average (or replacement data if unavailable) for the SPP minimum load hour corresponding to the season of the Light Load case, not to exceed each facility’s firm service amount. The methodology used to calculate replacement data is described in the ITP Manual. Solar resources will be modeled at zero MW output in the light load case regardless of the facility’s long-term firm transmission service amount.

14 “n” represents a unique numeric value. PSS®E requires each load placed at a bus to have a unique Load ID.
• On-Peak & Summer Shoulder Off-Peak models: Output of renewable resources with long-
term firm transmission service will be modeled in the case(s) at each facility’s latest five-
year average (or replacement data if unavailable) for the applicable seasonal SPP
coincident\textsuperscript{15} peak, not to exceed each facility’s firm service amount.

• SPP will make available the initial dispatch of renewable resources with long-term firm
transmission service based on historical seasonal five-year average with the initial model
pass of the each SPP MDWG model build. Any renewable resource modeling data submitted
to the PC, after the initial dispatch list is provided, will be dispatched at the seasonal state
dispatch percentage of the renewable resource’s nameplate amount.

• When an affected party disagrees with the dispatch amount for a facility, the affected
parties involved should coordinate to update the dispatch amount. If agreement cannot be
reached, the case can be brought to the MDWG for a decision.

• Responsibility for validating and providing renewable resource dispatch updates falls to the
affected parties.

• For resources that do not have firm service, $P_{\text{gen}}$ values should not exceed average historical
seasonal values for the Light Load, Spring Peak, Summer Peak, Summer Shoulder Off-Peak,
Fall Peak, and Winter Peak Cases. If historical data is unavailable then the rated net
capability of a resource determined according to SPP Planning Criteria section 7.1.5.3
should be followed.

SHORTFALL GUIDANCE PROCESS
Under no circumstances in the Near-Term Transmission Planning Horizon shall generating
resources be dispatched in excess of the firm transmission rights allotted to that resource. In the
Long-Term Transmission Planning Horizon, if the resources within a modeling area and firm
transactions from neighboring modeling areas are insufficient to serve customer load, the following
should be investigated as potential modeling solutions to the shortfall:

1. Coordinate reciprocal non-firm transaction(s) with other modeling area(s). All
parties are required to add their respective coordinated reciprocal record(s) to the
transaction worksheet of the EDST.

2. Future generation resources that have progressed, at minimum, to the
Interconnection Facility Study (per Attachment V, subsection 8.9) stage in the
Generation Interconnection (GI) queue, may be modeled (in the Long-Term
Transmission Planning Horizon models only) following these requirements.
   a. The in-service date shall be based on the expected in-service date of the GI study.
   b. In order to identify future GI queued generation, the unit name shall be the GI gen
      number (e.g. GEN-2017-898) and contain a unit ID of Zx (where x is any second ID
designation appropriate in PSS®E).
   c. Projects files that add future generation shall have the appropriate Type and Status
      which can be found in the SPP MOD Project Type/Status Matrix.

3. Future Exploratory Generation resources may be modeled in the Long-Term
Transmission Planning Horizon models following these constraints:
   a. In order to identify future Exploratory Generation, the unit ID of Zx (where x is any
      second ID designation appropriate in PSS®E) shall be used.
   b. When available, Exploratory Generation should be based upon the host TO Resource
      Plan.

\textsuperscript{15} SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.
c. Projects files that add future generation shall have the appropriate Type and Status which can be found in the SPP MOD Project Type/Status Matrix.
d. The addition of Exploratory Generation shall be consistent with modeling practices that minimize the impact to power flows in neighboring transmission systems (e.g., exercise diligence in siting the exploratory generator topologically proximate to the load that uses its resource).

**EXTERNAL RESOURCE MODELING**

**Purpose**
This procedure assures that members adhere to a uniform process when modeling external resources in SPP.

**Modeling Process**
If a member acquires external resources outside their Model Area, the following modeling process should be followed:
1. All buses should be assigned numbers that are in the host’s Model Area bus number range.
2. Area Number/Name should be the host’s Model Area number.
3. Zone Number/Name should be in the host’s Model Area zone range.
4. Generation Owner Number should be the owner’s designated ID number and percentage ownership.
5. The generation recipient should coordinate the output level and the inter-area transfer with the host control area.

**Owner Data and Line Mileage Data (SSAE Control)**

To meet the Statement on Standards for Attestation Engagement (SSAE) requirement for the Reactive Matrix (MW-Mile) the SPP models must include the most recent owner data and line-mileage data, which will be obtained from the current seasonal MDWG model; therefore, it is important that Members keep the data current in MOD.

The **MMWG Procedure Manual** contains information related to the following:
1. Zone Range and Modeling Area Assignments
2. System Codes
3. Utilized DC Lines

**Initial Run Review**

After all systems prepare and submit data, an initial run is made which assembles all system data, checks for errors, and results in a solved case. The initial run shows all entered data and diagnostic messages. This data is shown first in the initial run printout. Each system should review the data changes and solved case, making corrections as needed in the subsequent runs.

1. **Area Interchange**
   The area interchange report shows the area control bus, generation on the area control bus, and the net area interchange. The detail of area interchange among SPP systems is shown in the transaction data. The transaction workbook will include the NODE, Provider, and OASIS reservation number. The transaction workbook will use code DDD for transactions that do not have an OASIS reservation number. This data should be checked to ensure accuracy. Discrepancies in the transactions
between reporting systems will be noted in the diagnostic messages.

2. **Tie Line Metering**
The tie line report shows the tie lines and inter-company power interchange for each system. The tie line metered end should be verified, and should reflect line loss responsibility as accurately as possible. Any changes should be coordinated with the neighboring company involved.

3. **Area Totals**
The system generation and load should be checked on the system area summary. This data should be near expected values. The detail of generation is shown in the generation summary. If load is not the expected value, individual bus loads listed in the steady-state detail report should be examined. If loads were scaled from a reference case, the scaling factor should be checked. The load power factor should also be checked as power factors change seasonally. Check Power-factor of loads. The load supplying entities for the MDWG case types will validate each load power-factor with the most current system snapshot that represents that models load level (summer peak, winter peak, light load).

4. **Network**
Basic to the accuracy of the steady-state model is the accuracy of the network. The layout of the system representation should be checked. Purely conjectural facilities should not be included. Planned facilities which were modeled in previous steady-state models and have since been delayed or cancelled should be removed entirely from the steady-state model. These facilities cause solution problems for some steady-state programs if left in the model with an off-line status. Planned projects, including reactive resources such as capacitor banks, are to be included in the models. These projects are to be added through MOD in accordance with the MOD Type/Status Matrix of the Web Based Steady-State Model Development Procedure Manual.

5. **Review of Output**
The steady-state report should be checked for the flow on major transmission lines and selected bus voltages. This check can locate unusual results, which does not necessarily mean that data is in error, but rather indicates that additional checking of the model may be appropriate.

6. **Three useful reports for locating problems include:**
   a. The voltage summary,
   b. The overloaded branch summary, and
   c. The generation summary.

   a. **Voltage Summaries**
   Low or high voltages may be caused by a number of factors. Shunt devices may be sized inappropriately. Capacitors should have a positive value and reactors should have a negative value. (Check the CAP/REAC column of the steady-state report). The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are
used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

Transformer tap settings may also affect voltages. The steady-state report should be checked for tap settings. Particular attention to LTC-equipped transformers should be given to make sure the proper bus is regulated. A tap setting of less than 1.000 on the tap bus results in an increase in voltage on the non-tap bus. A tap setting greater than 1.000 on the tap bus results in a decrease in voltage on the non-tap bus.

The inclusion of LTC regulation makes tap setting more important. With LTC-equipped transformers, fixed taps may also exist. The LTC tap range should be adjusted to compensate for the effects of fixed taps if necessary. The minimum and maximum number of ULTC and NLTC taps should comply with common industry standard practices.

Transmission line or transformer impedance errors may also affect voltages if the errors are large. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

b. **Summary of Overloaded Branches**

This summary shows each overloaded circuit, the flow on the circuit, and the normal and emergency ratings. Overloading may be caused by an incorrect rating. Both normal and emergency ratings should be given. Emergency ratings must never be less than normal ratings, though the ratings may be equal. The impedance of a circuit element or of a parallel element may also cause overloading. See Section 6-A for guidelines of typical transmission line or transformer impedance data.

c. **Generation Summary**

All buses with generation as well as all buses with voltage regulation are shown in this summary. Generators should not be modeled as unregulated buses.

The MW ratings, Mvar ratings, machine base (MBASE), and ZSOURCE must be supplied for each generator. Generator PMAX ratings should represent the net capability of each machine connected to the bus. Ratings should be adjusted seasonally in consideration of scheduled outages. The generation should be shown on the correct bus. Generation must not exceed the rating. Generator MBASE values should be equal to the nameplate MBASE rating of the unit. Each unit should be explicitly modeled and listed in the SPP Generation tab of the EDST. The generator workbook will be updated to include both the saturated and unsaturated impedance for each machine. Fuel types, especially wind farms, should be identified in the appropriate column.

The reactive output limits (MAX and MIN) should be realistic values as defined in SPP Planning Criteria. For generators, a general rule of thumb sets MVAR limits as:

i. QT --- MAX = one-half of MW rating

ii. QB --- MIN = negative one-third of MW rating

If the slack bus generation changes significantly from the input value, it indicates an error in the model data. Regulated buses are not limited to generators, but also include other equipment such as synchronous condensers and static var controllers. If the actual voltage does not match the desired voltage, a reactive limit will be reached. The
desired voltage for each regulated bus should be checked seasonally.

The Generator Owners/Data Submitters of utility scale wind and solar resources shall provide an equivalent representation consisting of all collector bus(es) and the main power step-up transformer(s) from the collector bus(es) to the transmission point of interconnection (POI). Additionally, a single step-up transformer and feeder parameters for each connected generator model, from the generator terminals to a collector bus, shall be included in the equivalent representation, with wind/solar devices lumped together to represent the aggregate wind turbines or solar inverters in each collection network. The equivalent representation shall be an as-built representation (as reasonably as possible) with all transformer data reflective of manufacturer test report information. Any future changes or updates to equipment (wind turbines or solar inverters) or electrical topology shall include an updated equivalent representation to the Transmission Planner before submitting to the Planning Coordinator.

Generator facilities comprised of more than a single inverter (battery, flywheel, etc.) and other similar technology should have similar equivalent model representation. Figure 1 and Figure 2 below are illustrations provided for use as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation in the planning models.

Generator Owners/Data Submitters should coordinate with their host Transmission Owners to obtain valid SPP bus numbers for use in the equivalent representation of the generator resources. Bus names shall conform to the bus naming section of this manual. There are several industry best practice documents explaining how to represent equivalent representation of generator resources (examples: WECC Wind Power Plant Power Flow Modeling Guide and PV Plant Power Flow Modeling Guide).
Figure 1: Detailed Wind and Solar Farm Representation (Not to be used for planning models)

Figure 2: Equivalent Wind and Solar Farm Representation (Required representation for planning models)
Periodic Model Updates

After the annual update process is complete, it may become necessary to perform an update to the information contained in the model(s). Some of the reasons for updating the model(s) and the procedure for doing so are listed below.

System Impact Studies/Expansion Options Studies (Long-Term)

SPP performs transmission planning studies and assessments for various eligible customers. These model sets are developed in accordance with the SPP Planning Modeling Process and include models used for the SPP Transmission Expansion Plan, Transmission Service Studies, and Generation Interconnection Studies, which all use the data submitted to MOD as a base for model development.

MDWG Updates

At some point after the current models are extracted out of MOD some data will need to be updated to reflect pertinent changes to the system (i.e., lost or added transmission capability, lost or added generation, improved data, etc...) There are several ways of submitting changes to the steady-state models.

Two of these methods are:

1. Using the steady-state update procedure to update MOD.
2. Submitting a PTI, IDEV format file to perform the RDCH operation. **This method should only be used for profile changes. Each company should only submit one IDEV file per modeling pass. Under special circumstances topology changes can be submitted in an IDEV file as long as a MOD Project is submitted in MOD.**

   **It is imperative that any information submitted to SPP be error free and complete to avoid delays in the implementation of the changes.**

The most current update to the models will always be posted on the SPP file sharing site.

Program Operation

The SPP steady-state models are created, modified, and maintained utilizing the Power Technologies, Incorporated (PTI) Power System Simulator for Engineers (PSS®E) software package. The PSS®E program is installed on SPP computer facilities located in Little Rock, Arkansas.

PTI-PSS®E Data Format

Steady-State data is input to the models from computer text data files structured in the formats described in the PSS®E Program Operation Manual Volume I, Chapter 4: Section 1.1. All data is read in "free format" with data fields separated by a **comma (not blanks).** Each type of data category is terminated by the specification of a zero in the first field of the record with the exception of the model identification data.

Data is **added** to the SPP steady-state models as specified in these format structures for records where no corresponding component is found in the model. The **modification** of existing data in the model is accomplished using the same format structure, except that only the values that need modification are specified.

Data may also be deleted from the models. When a bus is specified for deletion, all associated data
for that bus will be removed (e.g., branches, transformers, generators, and loads). The user cannot delete a piece of equipment and then add it with new data. For example, to upgrade a bus from one voltage to another, the bus data must be modified. Data currently in the model is used as the default value for data fields not specified in the format.

Steady-State Solution

The steady-state solution will have “Area interchange control” with the “Tie Line and Loads” option selected to meet ERAG MMWG model building requirements.

Error Screening

The following data error screening checks will be used to check case quality:

1. Interchange and tie line data not matching the raw data will not be accepted until either the interchange data or the raw data are corrected. *
2. All CNTB errors shall be corrected. (Exceptions will be documented.)
3. All instances of mode=1 switched shunts with VHI – VLO < .005 per unit shall be corrected.
4. Any regulation by any regulating device of a bus more than one bus away, except where there is a three-winding transformer in which case no more than two buses away, shall be corrected.
5. All instances of voltage controlling bandwidth less than twice the transformer tap step size shall be corrected.
6. All transmission lines 69 kV and above, transformers with a secondary voltage of 69 kV and above, and Generator Step Up (GSU) transformers shall not have overloads (loading above 100% of RATE1) in the base case. Exception: 10 year cases may have overloads.

The effect of this check will be to delay acceptance of the applicable submittal until the problem is corrected.

STEADY-STATE MODELING REQUIREMENTS

GENERATORS

1. All steady-state generators, including synchronous condensers and Static VAr Compensators (SVCs) modeled as generators, shall be identified by a bus name and unit id. All other dynamic devices, such as switched shunts, relays, and HVDC terminals, shall be identified by a bus name and base kV field. The bus name shall consist of eight characters and shall be unique within the Eastern Interconnection. Any changes to these identifiers shall be minimized.
2. Where the step-up transformer of a synchronous or induction generator or synchronous condenser is not represented as a transformer branch in the steady-state cases, the step-up transformer shall be represented in the steady-state generator data record. Where the step-up transformer of the generator or condenser is represented as a branch in the steady-
state cases, the step-up transformer impedance data fields in the steady-state generator data record shall be zero and the tap ratio unity. The mode of step-up transformer representation, whether in the steady-state or the generator data record, shall be consistent from case to case within a model series.

3. Where the step-up transformer of a generator, condenser, or other dynamic device is represented in the steady-state generator data record, the resistance and reactance shall be given in per unit on the generator or dynamic device nameplate MVA. The tap ratio shall reflect the actual step-up transformer turns ratio considering the base kV of each winding and the base kV of the generator, condenser or dynamic device.

4. In accordance with PTI PSS®E requirements, the XSOURCE value in the steady-state generator data record must match data contained in dynamic model records and shall be as follows:

**XSOURCE Table:**

<table>
<thead>
<tr>
<th>GENERATOR TYPE</th>
<th>DESIRED PARAMETERS FOR XSOURCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous: Detailed Subtransient</td>
<td>Unsaturated sub-transient reactance ($X''_d$) [PU]</td>
</tr>
<tr>
<td>Synchronous: Non-Detailed Classical or Transient</td>
<td>Unsaturated transient reactance ($X'_d$) [PU]</td>
</tr>
<tr>
<td>Renewable: Wind Type 1 Wind Type 2</td>
<td>Unsaturated transient reactance ($X'_d$) of single machine [PU*] OR Locked rotor reactance (sum of rotor and stator leakage reactances) [PU]</td>
</tr>
<tr>
<td>Renewable: Wind Type 3</td>
<td>Unsaturated transient reactance ($X'_d$) of single machine [PU]</td>
</tr>
<tr>
<td>Renewable: Inverter-Based Solar PV Wind Type 4</td>
<td>$V_{rated} = \text{Rated Voltage} = 1.0 \ [PU] \ (assumed)$ $I_{rated} = \text{Rated Current From GO} \ [PU]$ $XSource = \frac{V_{rated}}{I_{rated}} \ [PU]$</td>
</tr>
<tr>
<td>Renewable: Wind Type 5</td>
<td>Unsaturated sub-transient reactance ($X''_d$) [PU]</td>
</tr>
</tbody>
</table>

* PU values should be based on the rated terminal voltage and machine MVA base

5. Generally, SVCs should be represented in steady-state as continuously variable switched shunts rather than as generators. In iterative steady-state solutions, a generator that reaches a VAR limit on solution iteration will lock at that value, but a switched shunt will move off the limit in a subsequent iteration if appropriate. PSS®E provides dynamic library models compatible with either representation. If a user model representing particular SVC
and the associated control features is to be used and that model assumes generator representation, the SVC should be represented as a generator in the steady-state.

6. Renewable generator facilities comprised of more than a single technology type should have similar, equivalent model representation for each technology type. Examples of multiple technology types at a single facility are: Type 3 and Type 4 wind turbines at the same plant, Type 3 wind turbines coupled with solar PV, solar PV coupled with battery storage, etc. Figure 1 and Figure 2 (located in the Initial Run Review Section) below are illustrations provided as guidance for the equivalent representations of such renewable resources; however, Figure 2 shall be the representation used in planning models.

Modeling of multiple equivalent machines for a single renewable facility is acceptable when trying to model:
   a. Different turbine manufacturers and/or types if the 2nd generation (or later) generic renewable models are not being used
   b. Equivalent collector circuits that are separated by a normally open breaker or switch at the collector substation
   c. Different development phases
      i. These representations should be combined as the phases are placed in service as applicable

OTHER DEVICES

1. Modeling Detail – Each bus should be assigned the appropriate area, owner, and zone. All transmission lines 115 kV and above and all transformers with a secondary voltage of 115 kV and above should be modeled explicitly. Significant looped transmission less than 115 kV should also be modeled.

2. Nominal Bus Voltage – All bus voltages are expressed as a phase-to-phase voltage. All buses should have a non-zero nominal voltage. Nominal voltages of buses connected by lines, reactors, or series capacitors should be the same. The following nominal voltages are standard for AC transmission and sub-transmission in the United States and Canada and should generally be used: 765, 500, 345, 230, 161, 138, 115, 69, 46, 34.5 and 26.7 kV. In addition, significant networks exist in Canada having the following nominal voltages: 735, 315, 220, 120, 118.05, 110, 72, and 63.5 kV.
   Nominal voltages of generator terminal and distribution buses less than 25 kV are at the discretion of the reporting entity.
   If transformers having more than two windings are modeled with one or more equivalent center point buses and multiple branches, rather than as a 3-winding transformer model, it is recommended that the nominal voltage of center point buses be designated as 999 kV. Because this voltage is above the standard range of nominal voltages, it can easily be excluded from the range of data to be printed in steady-state output.

3. Islanded Buses – Islanded buses shall not be modeled.

4. Generator Modeling of Loads – Fictitious generators should not be used to “load net” (by showing negative generation) a model of other nonnative load imbedded in steady-state areas. It is recommended that a separate zone be used to model such loads to allow exclusion from system load calculations.

5. Zero Impedance Branches – Bus ties that are opened to represent switching during contingencies may be modeled in detail. Zero impedance branches are permitted to model bus ties using $R=0.00000 + X=0.0001$ and $B=0.00000$. These values facilitate differentiating
between bus ties and other low impedance lines, utilizing the zero impedance threshold
THRSHZ in the PSS®E program. When connected between two voltage controlled
(generator, switched shunt, or TCUL controlled), bus ties or other low impedance lines
should be modeled using an impedance of $R=0.0001 + X=0.002$ and $B=0.00000$. This allows
use of near-zero impedance attached to controlled buses that will be large enough to avoid
significant solution problems.

6. Impedance of Branches In Network Equivalents – Where network representation has been
equivalenced, a maximum cutoff impedance of 3.0 p.u. should be used.

7. Negative Branch Reactances – Except for series capacitors, negative branch reactances do
not represent real devices. Their use in representing three winding transformers is
obsolete. Negative branch reactances limit the selection of steady-state solution techniques
and should be avoided.

8. Transformers – To adequately model transformers, the following parameters, at a minimum,
are required:
   a. Nominal voltage of windings and bus reference to which the appropriate winding is
      connected
      When entering transformer data, the rated voltage$^{16}$ for all applicable windings should
      be specified. For non-LTC transformers, the winding voltage should be set to the tap
      voltage.

      A recommended approach is to model three-winding transformers such that the
      winding buses map to the transformer windings as follows:
      - $H$, or High-Voltage, Winding $= Winding 1$
      - $X$, or Low-Voltage, Winding $= Winding 2$
      - $Y$, or Tertiary-Voltage, Winding $= Winding 3$

      A recommended approach is to model two-winding transformers such that the winding
      buses map to the transformer windings as follows:
      - $H$, or High-Voltage, Winding $= Winding 2$
      - $X$, or Low-Voltage, Winding $= Winding 1$

      The two-winding$^{17}$ transformer winding map is in this order by default since PSS®E
      requires all two-winding transformers with Load Tap Changers (LTCs) to specify the tap
      bus as Winding 1. While not all LTC transformers have the tap on the X winding, this is
      common with most transformers.

   b. Impedance(s)

      A recommended approach to modeling transformer impedance is to set the winding
      MVA base to the system MVA base which is 100 MVA, entered as positive sequence data
      in pairwise (delta) format. Care should be taken to when entering transformer
      impedance data to ensure that the data entered corresponds to the appropriate base
      (system or winding).

      Enter zero sequence data in the format appropriate to the connection code.

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$^{16}$ Care should be taken to enter the rated voltage, which may be different than the nominal voltage of the system
for all transformer windings. There can be a difference between the rated voltage of the system and the transformer
(nominal).

$^{17}$ Two winding representation in PSS®E allows the user to select which bus number (from or to) the winding 1
resides.
Connection codes <10:
  • The zero sequence data must be entered as T-model format

Connection codes >10:
  • The zero sequence data must be entered in pairwise (delta) format

c. Tap ratios
Depending on the PSS®E winding code used for the transformer, the setting should be either p.u. or kV. It should be noted, “tap ratio”, “winding ratio”, and “turns ratio” are synonymous.
  • For transformers with no taps, use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
  • For transformers with automatically adjusting, under-load tap changers (ULTC), it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio.
    - For parallel transformers, it is recommended to initially use nominal (“1.00” for p.u. or transformer nominal winding kV) for the tap ratio for both transformers in order to prevent circulating VARs.
  • For transformers with non-automatically adjusting, under-load tap changers (ULTC), it is recommended to use the tap ratio as set in the field.
  • For transformers with no-load tap changers (NLTC), it is recommended to use the tap ratio as set in the field.
  • It is recommended that Delta-Wye phase angle differences are incorporated appropriately in the models.

d. Minimum and maximum tap position limits
  • Minimum and maximum tap position limits (RMIN and RMAX) shall be modeled based on transformer test report or manufacturer nameplate data.

e. Number of tap positions (for both the ULTC and NLTC)
  • Under-load tap changers (ULTC) control bus, total number of tap positions, and tap setting shall be specified.
  • No-load tap changers (NLTC) total number of tap positions and the tap setting shall be specified.
  • Transformer tap positions are discrete. The total number of transformer tap positions is a fixed quantity and shall be entered. The maximum and minimum transformer tap positions represent the physical boundaries of the transformer’s capability to modify its winding impedance to achieve a control objective. Transformer tap changing control modes may include voltage regulation, as well as real and reactive power control. Automatically-adjusting under-load tap changing transformers (ULTC) shall specify a control mode, the bus that is being controlled, and the control limits\(^{18}\) defined by the maximum and minimum transformer tap positions.

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\(^{18}\) It is noted that PSS®E provides transformer tap changer limit fields called VMAX and VMIN, regardless of control mode. For example, if a real power control mode is selected, the user must enter MW quantities in the VMAX and VMIN fields.
• For transformers with untapped windings, the number of tap positions shall be “99” to indicate that there are no taps. PSS®E does not allow a value of “1” to be used as a tap position.

f. Regulated bus (for voltage regulating transformers)
   • The regulated bus is the location where the transformer is regulating voltage. Typically this regulated bus is connected to a transformer winding bus.
   • A limit difference of less than 0.0125 p.u. shall not be used when entering the regulated voltage band limits (VMAX, VMIN) for an automatically adjusting, under-load tap changers (ULTC) transformer.
   • It is recommended that the voltage band limits VMAX and VMIN be no less than 0.025 p.u., to prevent toggling of the ULTC during simulation iterations.

g. In-service status
   • In-service status, set to zero (0) if the device is not in-service.

h. Vector group and Connection code
   • The vector group shall match the topological configuration of the buses representing where the windings are connected (e.g. A 115/69 kV load serving transformer with a vector group of Dyn11 must show the winding 1 bus [Delta winding] as the 115 kV bus).
   • Transformer connection codes19 and transformer winding angle (phase displacement) shall be provided. The connection code data incorporates concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation. The transformer winding angle further specifies the inherent phase shift between transformer windings based upon configuration (vector group). Data Owners are reminded that changes to connection codes do not automatically alter the modeled phase displacement used for positive sequence load flow calculations.
   • The transformer core construction should be considered (shell type or core type) 20

i. Transformers Controlling Reactive Power Flow
   • The upper and lower limits of off-nominal turns ratio and the number of tap positions available are entered for winding 1 of transformers controlling reactive power flow. Default values of 1.1, 0.9 and 33 are representative of U.S. practice. The upper and lower MVAR limits are entered for transformers controlling reactive power flow and these limits should differ by at least 10 MVAR. Limits should accurately represent the actual operation of automatic control devices.


20 Reference the TPL-007-1 Data Collection Template User Guide document under the Transformers section/Core Type. https://www.spp.org/spp-documents-filings/?id=197519
9. Remote Regulation – Regulation of a bus voltage more than one bus away (not counting hidden center point buses of three winding transformers) from the regulating device should be avoided. The sign of parameter CONT determines whether the off-nominal turns ratio is increased or decreased to increase voltage at the bus whose voltage is controlled by this transformer.

10. Phase Shifting Transformers (PSTs) – Manufacturer tested capability and operational limits must be provided to SPP in order to allow corrective actions to be developed by SPP planning staff for transmission planning purposes.

PSTs will be represented in the planning models as Two-winding transformers with both windings at the same nominal voltage level. The active power flow into winding 1 is entered. The tolerance should be no less than 5 MW; i.e., a 10 MW dead band. The controlling band should be at least 10 degrees. The following characteristics should be considered by the entity submitting PST modeling data for the planning models:

a. Real-time operational auto or manual adjustment operation of the PST.

b. Real-time operational average MW flow for a particular season (e.g. average hourly MW flow is +18MW [directional based] during the Summer Peak Season, June 1 – September 30) in order to represent what is typically flowing through the PST during a particular season. This applies to PSTs that are not modeled for auto adjustment, in order to appropriately model the phase shift angle and relative MW flow, but should also consider the capability of the transformer regardless of the type of operation.

c. Real-time operational MW flow limits (e.g. ±20 MW).

d. Real-time operational phase shift angle range (e.g. -52.9° to 31.4°).

e. The applicable planning model impedance table should reflect the impedance correction adjustments as the phase shift angle moves through the various angle steps.

f. Applicable long-term firm transmission service levels for the PST.

11. AC transmission line or circuit modeling status – Out-of-service AC transmission lines or circuits should be modeled with an in-service status equal to zero. In-service AC transmission lines or circuits should be modeled with an in-service status equal to one.

12. Generator Step-Up Transformers (GSU) – When modeled implicitly, the GSU Resistance, reactance and tap setting (all in per unit values) shall be provided along with the Generator data. Whenever modeled explicitly, a GSU shall be modeled similar to a power transformer and the GSU nominal winding voltages, impedance(s), tap ratios, minimum and maximum tap position limits, number of tap positions, regulated bus (as applicable), normal and emergency ratings and in-service status data shall be provided. GSUs may be modeled explicitly as deemed necessary by either the transmission owner or the Regional Reliability Organization. Their modeling should be consistent with the associated dynamics modeling of the generator. Generator step-up transformers of cross-compound units should be modeled explicitly.

13. Generator modeling status – Out-of-service generators should be modeled with an in-service status equal to zero. In-service generators should be modeled with an in-service status equal to one.

14. Generator MW Limits – The generation capability limits specified for generators (PMIN and PMAX) should represent realistic seasonal unit output capability for the generator in that given base case. PMAX should always be greater than or equal to PMIN. Net maximum and minimum unit output capabilities should be used unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

15. Generator MVAR Limits – The MVAR limits specified for generators (QMIN and QMAX) should represent realistic net unit output capability of the generator modeled. QMAX should always be greater than or equal to QMIN. Net maximum and minimum unit output
capabilities should be given unless the generator terminal bus is explicitly modeled, the generator step up transformer is modeled as a branch, and unit load is modeled at the bus or buses from which it is supplied.

16. **Small Generators, Capacitors, and Static VAR Devices** – Small generators (e.g., 10 MVA), small capacitors, and small SVCs have limited reactive capability and cannot effectively regulate transmission bus voltage. Modeling them as regulating increases solution time. Consideration should be given to modeling them as non-regulating by specifying equal values for QMIN and QMAX. If several similar machines or devices are located at a bus and there is a need to regulate with these units, they should be lumped into an equivalent to speed solution.

17. **Coordination of Regulating Devices** – Multiple regulating devices (generators, switched shunt devices, tap changers, etc.) controlling the bus voltage at a single bus, or multiple buses connected by Zero Impedance Lines as described above, should have their scheduled voltage and voltage control ranges coordinated. Also, regulated bus voltage schedules should be coordinated with the schedules of adjacent buses. Coordination is inadequate if solving the same model with and without enforcing machine regulating limits causes offsetting MVAR output changes greater than 500 MVAR at machines connected no more than two buses away.

18. **Over and Under Voltage Regulation** – Regulation of voltage schedules exceeding 1.10 per unit, or below 0.90 per unit should be avoided.

19. **Flowgates** – All transmission elements comprising part of one or more flowgates should be included in the data submitted by each region. A flowgate is a selected transmission element or group of elements acting as proxy for the transmission network representing potential thermal, voltage stability, rotor angle stability, and contractual system constraints to power transfer.

20. **Fixed Shunts** – All fixed shunt elements at buses modeled in the steady-state should be modeled explicitly (not as loads or included with load). The status should be set to zero if the shunt is not in service. Fixed shunt elements that are directly connected to a bus should be represented as bus shunts. Fixed shunt elements that are directly connected to and switch with a branch should be represented as line shunts.

21. **Switched Shunts** – Switched shunt elements at buses modeled in the steady-state should be modeled explicitly. Continuous mode modeling using a switched shunt should not be used unless it represents actual equipment (e.g. SVC or induction regulator). The number and size of switched admittance blocks should represent field conditions. The bandwidth (difference between VSWHI and VSWLO) of switched shunt devices should be wide enough that switching one block of admittance does not move the voltage at the bus completely through the bandwidth, thus causing solution problems at the bus. It is recommended that the minimum voltage bandwidth be 4% if only switched shunts are used to regulate voltage. Switched shunts should not regulate voltage at a generator bus, nor should they be connected to the network with a zero impedance tie.

22. **Static Var Systems** – Static var elements should be modeled with accurate reactive power (leading/lagging) limits. An accurate voltage set point, as well as any associated fixed/switched shunt equipment should also be modeled based on actual seasonal operation. Out-of-service Static Var Systems should be modeled with an in-service status equal to zero. In-service Static Var Systems should be modeled with an in-service status equal to one.

23. **DC Transmission systems** – DC transmission systems must be represented with a sufficiently detailed model to simulate its expected behavior.

24. **Interchange Tolerances** – In a solved case, the actual interchange for any area containing a Type 3 (swing) bus should be within 25 MW of the specified desired interchange value.
(Note that PSS®E does not enforce the interchange deviation for areas containing Type 3 buses.)

25. **Scheduled Interchange vs. Scheduled Tie Line Flows** – Scheduled interchange between areas directly connected solely by ties with flows controlled to a specific schedule (PAR-controlled AC or DC) should be consistent with the PAR or DC scheduled flows.

26. **Other information requested by the PC or TP** – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

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**Causes of Non-convergence and Problems in Merged Base Case Models**

**Causes of Non-convergence**

1. A line whose impedance is very small as compared to that of a line connected in series with it.
   (Solution: If possible, add impedance of short and long series-connected lines and represent as one line.)

2. Tie lines are missing because they were not picked up by model creation or tie lines are connected incorrectly.

3. An impedance or susceptance value whose magnitude is extremely large. A decimal point may have been misplaced, or large cutoff impedance was specified during Equivalencing.

4. A system's regulating (slack) bus is in a different system. This is probably due to an incorrect data entry in changing a model.

5. An isolated system (island) has been inadvertently created. Voltage phase divergence will be flagged immediately and the program will stop calculating after the first iteration.

6. Unrealistic tap changing transformer tap limits.

7. Radial system is very large.

8. Poor voltage regulation such as:
   a. Unequal voltage schedules at generating units connected by a low impedance line.
   b. Regulation of a radial line at both ends at unequal voltages.
   c. (Solution: Do not regulate a radial bus; hold MVAR output of a radial bus constant at the value obtained in last iteration.)
   d. Conflicting voltage regulation.
   e. Unreasonably small voltage range for switched shunts.
   f. Remote regulation of more than one bus away.


10. Not solvable from flat start.

11. Fictitious regulation of buses.

12. Extremely low voltage schedules.

13. Not following the approved MMWG sign convention for phase shifters (see page 3 of this Appendix) or not adhering to minimum MW tolerance for phase-shifting-under load transformers.

14. Zero or very low reactance branches. Minimum reactance = 0.0001 per unit.

15. Inconsistent representation of delta-wye transformers, typically by two companies interconnected at both voltage levels.
**TROUBLESHOOTING**

1. Duplicate bus names in an area(s).
2. The data will not permit steady-state calculations, such as:
   a. Zero voltage regulation, resulting in division by zero. Notify Regional Coordinator.
   b. Interchange does not net to zero. Save the data but do not calculate until the Coordinator has given instructions for correcting the data.
   c. High R/X ratios in equivalent area causing non-convergence. Delete line or reduce ratio.
3. Missing tie lines. These tie lines may or may not be in the base case model. The program flags the tie lines as missing because of its tie line checking routine. A review of the data dump will verify the inclusion of a tie line if it is included and has been flagged as missing. Likewise, the validity of the error message will be verified by a review of the data dump.
4. Phase Shifting Transformers
   a. The first-named bus in the branch data is taken as the “From” bus and the second-named bus is taken as the “To” bus. The “From” bus is also taken as the tapped bus.
   b. If phase shift angle is specified in CDF as positive, $\theta_A < \theta_B$.
   c. Assuming $\theta_A$ and $\theta_B$ stay relatively constant for small changes, an increase in this positive phase shift angle will tend to change the voltage phase angle of Bus A in a lagging direction relative to that for Bus B. This causes an incremental increase in real power flow in the direction of B to C regardless of the direction of the initial real power flowing through the transformer.
   d. A desired positive real power flow into the phase shifting transformer at the "From" bus or tapped bus is specified with positive real power limits.
   e. The "Controlled Bus" specified should be the same as the tapped bus to be consistent and avoid confusion.

**Note:** The PTI PSS®E steady-state program currently being used by AEP to process MMWG models requires the above convention. Therefore, it is desirable that all phase shifter models sent to AEP conform to this convention. If the data submitted does not conform to the above convention, AEP must be notified so that appropriate corrections can be made.

**BALANCING AND TRANSACTIONS**

A core principal of steady-state power flow modeling is the balance between load and generation. A system swing generating unit is a fundamental requirement of the modern formulation of the linear power flow problem (net complex power injection into nodal admittance network). In the balanced three-phase power flow formulation, a swing generator serves the imbalance of power for the entire electrical network. However, in real power systems, Balancing Authorities ensure that frequency regulation is achieved by matching generation to load within a subsection of the entire interconnected power system. Thus, in most power flow software, a vast impedance network may be segregated into groups of busses representing a model area. While typically analogous to a...
Balancing Authority Area or control area, the concept of a model area is straightforward: model areas allow the electrical network to be sectioned in such a way as to pool together generation, loads, and losses for the purpose of scheduling power flows throughout the electrical network. Model areas are not limited to being demarcated by physical load balancing boundaries; on the contrary, model areas are very effective at allowing individual generation and load-serving companies to properly allocate resources and demand, including transactions with other model areas. While most power flow software enforces that each generating unit inherits its model area designation from the bus to which it is connected, many modern power flow software packages allow ZIP\textsuperscript{23} loads and induction machine loads to be assigned to model areas that may be different than the busses to which they are connected. In this way, each generating unit and load is grouped into common balancing pools, represented by the model area (Figure 1).

![Model area diagram](https://via.placeholder.com/150)

**Figure 1. Example of interconnected model areas.**

To be clear: it is inappropriate to refer to either a “generation area” or a “load area”. Instead, it is important to understand that the modeling concept of the “Area” field designated for bus, load, and generation refers to the model area to which that model object belongs. To reiterate, the model area to which a load is assigned indicates which generation resources will serve that load, independent of the model area of the bus to which that load is attached. This concept is of particular importance when interchange is used to obtain power flow solutions.

\textsuperscript{23} ZIP refers to constant impedance, constant current, or constant power load representations, including a combination of each.
Within each model area that contains generating units, a single generating unit must be designated as the slack machine. While the dispatch (Pgen) of each non-slack generating unit is set to a prescribed value, the slack machine dispatch varies to compensate for any imbalance within the model area. In many cases, load obligations and transmission losses associated with delivering power to the loads within a model area may not be totally served by the capacity of resources in-service within a model area. In these situations, inter-area transfers are common, representing power purchase agreements (PPA) that reflect the firm purchase or sale of power from generation resource in one model area to another for the purpose of serving load. Similarly, intra-area transfers representing contractual or PPA obligations between resource and load owners within a model area are also common. In total, all inter- and intra-area transfers are referred to as “transactions” and must be properly accounted for to achieve power flow model balancing and accurate model area tie-line loading.

Across the entire interconnected impedance network, one-and-only-one generating unit must be designated as the system swing unit. The system swing serves any overall imbalance arising from imbalanced exchanges between individual model areas. In its simplest expression, the model area designation facilitates the analysis of scheduled power flow between interconnected regions of the impedance network, which is useful for assessing conventional tie-line loading. More broadly, however, the use of model areas allows exchanges of generating resources that are intended to serve loads that may be very distant from the actual generating unit, giving rise to bilateral transactions across model area boundaries, integrated market operations, and efficient resource dispatch, as well as others.

Load is generally served by generation resources within a common model area. Likewise, both the load and the bus to which the load is connected reflect a common model area (as shown in the Area field of each). The same principle applies to transacted resource-to-load; loads that serve as the sink portion of a transacted real power quantity will reside in the model area of the sink Data Owner (and may retain the load ID of the Data Owner of the load itself). Exceptions are called pseudo-ties, representing where the resource that serves the load is outside of the model area where the load resides. Pseudo-tied loads are typically found when the Area field assigned to the load is different than the Area field of the bus, to which the load is connected, however generation pseudo-ties are possible, as well. For modeling purposes, pseudo-tie representations are permitted between two model areas within the SPP Balancing Authority (referred to an intra-SPP pseudo-tie), as well as between a model area within the SPP Balancing Authority and a model area of a non-SPP Balancing Authority (referred to an inter-SPP pseudo-tie). Intra-SPP pseudo-ties can be an effective means of differentiating which model area provides resource to unique load delivery obligations, but may be problematic if used to avoid proper resource, load, and loss accounting through model area transactions. Separately, inter-SPP pseudo-tie arrangements are typically unique contractual arrangements where firm transmission service (e.g., network services, point-to-point) has been pre-arranged to direct resource from/to an external model area, into/out of a model area where the load resides (see Figure 2). Inter-SPP pseudo-tied loads are generally an exception to the norm and the use of inter-SPP pseudo-tied loads should be justified (e.g., reference to an SPP load-balancing meter point, pseudo-tie registration in the SPP marketplace, etc.). Data Owners shall not create pseudo-tie modeling representations of load that incorporates fictitious topology; Data Owners may create pseudo-tie modeling representations of generation necessary, given the load flow software constraints.
Transactions Data Requirements

Data Owners shall submit all transactions data via the MDWG EDST. Additionally, Data Owners shall:

1. Coordinate all bilateral transactions data with all Data Owners who are party to the transaction, prior to submitting the data.
2. Submit only the bilateral portion of the transaction for which the Data Owner is responsible. For example, in a bilateral transaction between two Data Owners (SPP-members), each Data Owner shall submit one half of the transaction (source or sink). In the case of a bilateral transaction between a Data Owner (SPP-member) and a non-SPP member, such as a MISO-member, the Data Owner (SPP-member) shall submit their portion (source or sink) of the bilateral transaction, upon coordination with the non-SPP member. SPP staff will then submit the non-SPP member portion (source or sink) of the bilateral transaction.
3. Review and update transactions data according to the model building schedule.
4. Load and resource transactions may be inter-area (i.e., reciprocal transaction from an SPP Market Participant to another SPP Market Participant, both within the SPP Balancing Authority Area) or external area (i.e. traditional BA-to-BA interchange). Transactional data collected by Data Owners often have tens of kilowatts precision. However, for the purposes of the ERO, or its designee, Interconnection-wide models, external net interchange schedules are required to be entered as whole MW quantities. Therefore, Data Owners shall submit transaction data according to:
a. Inter-area transactions (transactions of load and resource that are wholly contained within the SPP Balancing Authority Area) are preferred to be integer values (i.e. whole MW); however, shall not exceed tens of kilowatt precision (i.e., two decimal MW precision; 0.01MW).

b. External area transaction (i.e. scheduled net interchange between the SPP Balancing Authority and an external Balancing Authority) shall be rounded to the nearest integer (i.e. whole MW).

5. Ensure that source transactions have positive polarity, while sink transactions have negative polarity (Figure 3 and Figure 4).

**Figure 3. Example of Inter-area transfer (transaction).**

<table>
<thead>
<tr>
<th>Model area</th>
<th>From Area</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>Area 1</td>
<td>Area 1</td>
<td>Data Owner A</td>
<td>Data Owner A</td>
<td>2</td>
<td>Area 2</td>
<td>Data Owner B</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
<td></td>
</tr>
<tr>
<td>Not SPP</td>
<td>Area 2</td>
<td>Area 2</td>
<td>Data Owner B</td>
<td>Data Owner A</td>
<td>1</td>
<td>Area 1</td>
<td>Data Owner A</td>
<td>ABC111</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
<td></td>
</tr>
</tbody>
</table>
Intra-area Bilateral transaction description

Data Owner A exports MW to Data Owner C
Data Owner C imports MW from Data Owner A

Transaction accounting in Data Submittal Workbook

<table>
<thead>
<tr>
<th>PC</th>
<th>From Area #</th>
<th>From Area</th>
<th>From Resp Entity #</th>
<th>From Resp Entity Name</th>
<th>To Area #</th>
<th>To Area</th>
<th>To Resp Entity #</th>
<th>To Resp Entity Name</th>
<th>ID</th>
<th>Start</th>
<th>Stop</th>
<th>Firm</th>
<th>201x Series MDWG Model - 18G</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>XYZ112</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>MW</td>
</tr>
<tr>
<td>SPP</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner C</td>
<td>1</td>
<td>Area 1</td>
<td>1</td>
<td>Data Owner A</td>
<td>XYZ112</td>
<td>12/1/2013</td>
<td>3/1/2020</td>
<td>X</td>
<td>-MW</td>
</tr>
</tbody>
</table>

Figure 4. Example of Intra-area transfer (transaction).

6. Complete the following required EDST data fields for each source and sink portion of a bilateral transaction:
   a. Planning Coordinator (PC).
   b. From Area #.
   c. From Area Name.
   d. From Responsible Entity #.
   e. From Responsible Entity Name.
   f. To Area #.
   g. To Area Name.
   h. To Responsible Entity #.
   i. To Responsible Entity Name.
   j. Transaction ID.
   k. Transaction Start date.
   l. Transaction Stop date.
   m. Firm or Non-Firm Transaction.
   n. Transaction quantity (in MW) for all appropriate seasonal MDWG Model Series cases.
7. When a part or all of a bilateral transaction is referenced by an Open Access Same-Time Information System (OASIS) number, used by the marketer for scheduling, enter the OASIS number in the appropriate EDST field.

8. The following EDST information is reserved for SPP staff usage and is not required from the Data Owner of each bilateral transaction:
   a. From Attributes.
   b. To Attributes.
   c. Link Number.
   d. Plant.
   e. Capacity.
   f. Roll Over Rights.
   g. S0 Scalable.
   h. S5 Scalable.
   i. OASIS Comment.
   j. Comments.
   k. Related Reference.

Transaction Update
The transaction workbook should be updated to show a transaction from the control area where external resource is located to the generation owner control area. If the external resource is owned by multiple owners, then multiple transactions should be modeled.

The SPP transaction workbook must not include transactions for sales to loads in other control areas if the loads are specifically identified with source control area number. If the loads in an external control area are not identified with the source control area's number, then a transaction is necessary to schedule to this load. See example below for more details for a load that Source Area XXX has the obligation to serve:

**No Transaction Needed**
Source Area: XXX
Sink Area: YYY
Sink Load: XXX

**Transaction Needed**
Source Area: XXX
Sink Area: YYY
Sink Load: YYY

Loads may be modeled on the foreign area bus as long as it is identified as belonging to the owning area.

SPP will identify remote SPP loads in the base cases, pass 1, pass 2, and pass 3 models.

Transactions modeled in all base cases should be limited to expected firm schedules and should not
include other transfers such as emergency power or opportunistic economy energy even though they may be provided for in contractual agreements. Due to FERC’s ruling of Roll-over rights, Long Term Firm Transactions should be considered in the models that extend into the future even if the transaction has a stop date. For a transaction to be considered firm, the transaction must be confirmed at both the source end and the sink end. Southwest Power Pool will do its best to confirm delivery of transactions outside of the Pool boundaries.

Firm transmission load includes capacity dependent interruptible loads with buy through provisions. In other words load that may be interrupted if the source runs out of capacity should still be modeled if the load has a choice and opportunity to purchase power from another source. This firm transmission load should be modeled in all cases. The load modeling entity is responsible for scheduling the power from a source and updating the transaction worksheet (see Appendix VIII).

System representatives should be responsive with good modeling techniques. SPP data models are used by individual systems for studying future needs in developing construction forecasts. Not planning a major expenditure by one year due to inaccurate data could be very expensive, since funding allocation for major construction projects requires more time resources. In addition, ATC, megawatt-mile and incremental losses are currently being calculated with these Steady-State models. With the large amount of interconnection within SPP, the impact of one system on another must be recognized and respected. Therefore, each system should prepare data consistent with its most recent official system forecasts in all data submitted to SPP including Energy Information Agency (EIA-411) Data. It is also important that the models represent the expected operation of the SPP system consistent with this manual and Planning Criteria.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models. Member updates for errors found due to contingency analysis are to be submitted during the next member data submission period per the latest MDWG model building schedule.

**SUBSTATION NODE-BREAKER MODELING**

Detailed substation node-breaker data is fully integrated into the PSS®E engine beginning with version 34. Substation node-breaker data is an extension to the bus-branch model, and is a container of nodes and switching devices. With the node-breaker data, there are a few data fields that represent the substation that must be uniquely specified within SPP, as well as the Eastern Interconnection; therefore, requirements must be set in place. For this section, the term substation also includes switching station.

Data Submitters shall submit node-breaker modeling information for any Extra High Voltage (EHV) substations within the SPP footprint in the approved format; node-breaker modeling information for non EHV substations may also be submitted.
SUBSTATION NUMBERING
The substation number should reflect the bus number of the highest voltage bus modeled at the station. By picking an existing bus number for the substation to represent the substation number, this ensures uniqueness in the model. The existing bus-branch model for a substation may be modeled with more than one bus for the same base kV, at which time a choice must be made. Preferably the bus number that has the most elements connecting to it should be used, and typically this is the lower bus number, however, it is up to the discretion of the Data Submitter to pick a bus number.

Example:
This one-line diagram shows that STATION A has only one 345kV bus, but since there is a reactor in that substation, MDWG might model another bus # 99902 for that reactor. This new bus # is only in PSSE and not in the one-line diagram or EMS model, thus the substation # should be 99900 and not 99902 since 99900 has the most elements connected to it.

**SUBSTATION NAMING CONVENTION**

The substation name should reflect the substation name with an SPP identifier and must be unique to the Eastern Interconnection. Substation names can have up to 40 characters, and the naming convention shall include a prefix of “SPP_”, followed by the substation name as determined by the Data Submitter, up to 36 characters. Additionally, the substation names shall be limited to alphanumeric characters, hyphens, and underscores.

**Example: Substation Name: “XXXXYYYY”**

- XXXX represents an “SPP_” prefix (4 characters including underscore)
- YYYYY represents the specific station name determined by the company (up to 36 characters)
- Example: “SPP_TECUMSEH_HILL” or “SPP_WERE-TECUMSEH-HILL”

**SUBSTATION PHYSICAL DATA**

Additional physical information is retained as part of the node-breaker Substation network record. This information is used directly for geomagnetically-induced current calculations and indirectly for displaying relative bus locations on a single-line diagram. Geographic latitude and longitude shall be submitted in decimal degrees with at least three decimal precision (e.g., 45.001) for each substation that includes equipment operated at 200kV and above. Only positive decimal degree values between 25°N and 50°N latitude (e.g., 25.000 to 50.000) and longitudes to the west of the Prime Meridian between 85°W and 115°W (e.g., -85.000 to -115.000) are acceptable. Substation grounding resistances shall be submitted in Ohms with at least one decimal precision (e.g., 0.2 Ohms) or, in the rare instance when a substation is ungrounded, as “-1”.

**SUBSTATION NODES**

Substation nodes create the mapping for the node-breaker model. Minimal information is required for these including Node Number, Node Name, and the Bus Number that they are represented within. Node numbers need to be unique to that substation.

**SUBSTATION SWITCHING DEVICES**

Substation switching devices need to be modeled in order to capture the full impacts of a detailed substation node-breaker model. A switching device name does not need to be unique to that
substation. There are a few different device options including a breaker, which acts as an interruptible device in the event of a fault, a switch, which is used to simulate a manual opening of a device, or a generic connector, which is used to represent bus work without an applicable switching device. Although higher levels of detail for a substation node-breaker model are not required to appropriately simulate contingency events, fault current interrupting devices shall be modeled. By modeling these devices, advanced contingency events can be automatically identified during analysis.

Example:

The diagram on the left is a one-line diagram with various switching devices whereas the diagram on the right shows the same topology translated into a node-breaker model in PSS®E.

Similar to branches, switching devices have sets of ratings. These ratings are optional, but if used, should represent Rate 1 (normal, continuous) and Rate 2 (emergency) entered in the first two fields (RATE1 and RATE2, respectively) for each seasonal model. Although higher levels of detail for a substation node-breaker model allow for ratings of terminal equipment and breakers to be modeled explicitly, the branch (line and transformer) model ratings should continue to consider this equipment as part of its rating. This is to allow for the bus-branch model to continue to have accurate ratings incorporated in the models if the substation node-breaker model is not used. Breaker interrupting capability ratings shall not be included as part of the ratings for switching devices.
**MDWG MODEL QUALITY ASSURANCE**

Data Owners are expected to ensure their data is correct before submitting to SPP. Data correction or addition by MDWG or SPP Staff is considered the last resort and will follow the SPP quarterly MOPC reporting process.

The model building process is split into incremental passes where Data Owners, Data Submitters, and SPP Staff compile new or updated modeling information with prior information to create a revised set of model cases. Ultimately, this process culminates with a final pass that yields a set of model cases ready to be approved by MDWG. Once approved, this set of approved MDWG model cases is available for use by stakeholders.

To assess the efficacy and completeness of the modeling data that comprises the model sets, SPP Staff makes two synopses available upon each completed model pass: DocuCode and an AC Contingency Calculation (ACCC) summary. Prompt and thorough review by Data Owners and Data Submitters helps assure case quality as the model building process progresses through to completion.

**DocuCode Fidelity Checks**

SPP Staff uses an automated routine to summarize and tabulate model case information for succinct end-of-pass review. The DocuCode tables include basic case information, as well as highlight unacceptable model data residing in the case set. The following unacceptable data shall be addressed in each model pass and shall be corrected prior to the MDWG approval of the final model set:

<table>
<thead>
<tr>
<th>Unacceptable model data</th>
<th>Means to correct unacceptable data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Branch Overloads</td>
<td>Resolve or designate as an “Exception.”</td>
</tr>
<tr>
<td>Voltage-controlled Bus Check (CNTB) Errors</td>
<td></td>
</tr>
<tr>
<td>Gen Reactive Limit Power Factor</td>
<td></td>
</tr>
<tr>
<td>Poor Load Power Factor</td>
<td></td>
</tr>
<tr>
<td>Small Voltage Band Shunts</td>
<td></td>
</tr>
<tr>
<td>Small Voltage Band Transformer</td>
<td></td>
</tr>
<tr>
<td>Transformer (three-winding) Overloads</td>
<td></td>
</tr>
<tr>
<td>Connection Code 4 Transformer (Sequence Data)</td>
<td></td>
</tr>
<tr>
<td>Wye Delta GSUs (Sequence Data)</td>
<td></td>
</tr>
<tr>
<td>SEQ Read Warning (Sequence Data)</td>
<td></td>
</tr>
<tr>
<td>Branch Rating Errors</td>
<td></td>
</tr>
<tr>
<td>Bus Voltage Violations (&gt;1.10pu or &lt;0.90pu)</td>
<td></td>
</tr>
<tr>
<td>Default Branch Length</td>
<td></td>
</tr>
<tr>
<td>Default Branch Owner</td>
<td></td>
</tr>
<tr>
<td>Gen Rsource-Xsource Ratio</td>
<td></td>
</tr>
<tr>
<td>Incorrect Branch kV</td>
<td></td>
</tr>
</tbody>
</table>
Mbase Below Pmax  
Node Voltage Regulation  
Offline Missing Slack Machines  
Raw Read Warnings  
Transformer Voltage Band Limits  
Wind Control Mode  
Wind Machine Voltage  
Zero Impedance ID  
Missing Generator Data  
Default Branch Seq Data (Sequence Data)  
Negative Delta Tertiary Reactance (Sequence Data)  
Retired Gen GSU Conflicts (Sequence Data)

Dynamic unacceptable model data may be modified by SPP and coordinated with the applicable Data Submitter. Lack of response by the Data Submitter will be considered as acceptance of the modified data until the next model build pass.

In rare occasions, model data identified as unacceptable in the DocuCode checks are legitimate exceptions. When allowed by the table above and requested by the applicable Data Owner or Data Submitter, unacceptable model data shown in DocuCode may be redesignated as an MDWG “Exception” by SPP Staff based on Data Owner or Data Submitter request. All MDWG “Exception(s)” will be separately annotated in the DocuCode summary.

Under explicit conditions, the MDWG and SPP Staff must proactively protect the data integrity of a model case(s) when unacceptable data persists in subsequent model passes. An uncommon scenario necessitating that specific unacceptable model data be overridden occurs when a Data Owner or Data Submitter does not respond to or resolve unacceptable model data. In this limited and targeted situation, the MDWG in conjunction with SPP Staff may act to modify unacceptable model data: when allowed by the table above, unacceptable model data may be overridden to a default quantity determined by engineering judgement (e.g., a non-responsive Data Owner has both VSWHI and VSWLO voltage setpoints for a switched shunt set at 1.00 per unit; these quantities would be overridden and replaced with 1.03 and 1.00 per unit, respectively). Neither MDWG, nor SPP Staff, assumes the obligation of the non-responsive Data Owner or Data Submitter when substituting overridden data for unacceptable data and the act of substitution is made in the interest of overall model integrity. All MDWG “Overridden” data shall be separately annotated in the DocuCode summary, reflecting both the overridden unacceptable data and the replacement data used.

**AC Contingency Analysis**

SPP will perform AC Contingency Analysis on all models contained in the steady-state case type set. The purpose of this contingency analysis is to validate the models and provide meaningful feedback to Data Owners and Data Submitters. Data Owner / Data Submitter updates to address modeling errors found from contingency analysis should be submitted during the next data submission.
period per the latest MDWG model building schedule.
SECTION 4: DYNAMIC DATA REQUIREMENTS

The MDWG Dynamic models reflect detailed dynamic model representations for SPP resources and equivalized external representations of external resources beyond specified tiers in reduced cases and detailed dynamic model representations for all of the Eastern Interconnection resources in full cases. The initialized no-fault models can be solved with quarter-cycle and half-cycle time steps. The MDWG Dynamic model update is used to support SPP reliability studies and ERAG MMWG Dynamic modeling requirements. It is important for all generating entities that interconnect to the SPP transmission to support the SPP RTO with current detailed dynamics data in the proper SPP model format. The current MDWG Dynamic model format is PSS®E dynamics DYRE and RAWD formats.

The Dynamic model data includes:
1. Steady-State models
2. Files applied (if applicable) to steady-state models for dynamic initialization purposes
3. Dynamic model data in Siemens PTI PSS®E DYRE format
4. User written model source and object code

The schedule for submission of Dynamic data and list of MDWG Dynamic models (case types) can be found on the SPP corporate website, www.spp.org.

Dynamics Data Submittal Requirements and Guidelines

1. All synchronous generator and synchronous condenser modeling and associated data shall be detailed except as permitted below. Detailed generator models consist of at least two direct axis circuits and one quadrature axis equivalent circuit. The use of non-detailed synchronous generator or condenser modeling shall be permitted for units with nameplate ratings less than or equal to 50 MVA under the following circumstances:
   a. Detailed data is not available because manufacturer no longer in business.
   b. Detailed data is not available because unit is older than 1970.
   The use of non-detailed synchronous generator or condenser modeling shall also be permitted for units of any nameplate rating under the following circumstances only:
   a. Unit is a phantom or undesignated unit in a future year MMWG case.
   b. Unit is on standby or mothballed and not carrying load in MMWG cases.
   The non-detailed PSS®E model types are GENCLS and GENTRA. When complete detailed data are not available, and the above circumstances do not apply, typical detailed data shall be used to the extent necessary to provide complete detailed modeling.

2. All synchronous generators and condensers shall also include representations of the generator, excitation system, turbine-governor, power system stabilizer, and reactive line drop compensating circuitry. The following exceptions apply:
   a. Excitation system representation shall be omitted if unit is operated under manual excitation control.
b. Turbine-governor representation shall be omitted for units that do not regulate frequency such as base load nuclear units, pumped storage units in pumping mode and synchronous condensers.

c. Power system stabilizer representation shall be omitted for units where such device is not installed or not in continuous operation.

d. Representation of reactive line drop compensation shall be omitted where such device is not installed or not in continuous operation.

3. All other types of generating units and dynamic devices including induction generators, static VAR compensators (SVC), high-voltage direct current (HVDC) systems, static compensators (STATCOM), Flexible AC Transmission System (FACTS), wind turbines, and photovoltaic systems shall be represented by the appropriate PSS®E dynamic models.

4. All demand data shall include a load model which represents the expected dynamic behavior of the loads. Non-scalable loads greater than or equal to 10 MW are required to have a dynamic load model representation. For all other types of loads, absent detailed dynamic load models, the real portion (MW) of all demand data is converted to 100% constant current and the reactive portion (Mvar) of all demand data is converted to 100% constant admittance.

5. Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.

6. Standard PSS®E dynamic models shall be used for the representation of all generating units and other dynamic devices unless both of the following conditions apply:
   a. The specific performance features of the user-defined modeling are necessary for proper representation and simulation of inter-regional dynamics, and
   b. Standard PSS®E dynamic models cannot adequately approximate the specific performance features of the dynamic device being modeled.

7. When user-defined modeling is used, written documentation shall be supplied explaining the dynamic device performance characteristics. The documentation for all user-defined models shall be provided as a separate document and must include the characteristics of the model, including block diagrams, values and names of all model parameters, and a list of all state variables. Any benign warning messages that are generated by the model code at compilation time should also be documented.

   Source code for User Models shall be submitted in the FLECS language of the current PSS®E revision, C, or FORTRAN. User models created in MATLAB/SIMULINK are not permitted because users of the SDDB cannot run them without purchase of additional software.

8. Netting of small generating units, synchronous condensers, or other dynamic devices with bus load shall be permitted only when the unit or device nameplate rating is less than or equal to 20 MVA. (Note: any unit or device which is already netted with bus load in the MMWG cases need not be represented by a dynamic model.)

9. Lumping of similar or identical generating units at the same plant shall be permitted only when the nameplate ratings of the units being lumped are less than or equal to 50 MVA. A lumped unit shall not exceed 300 MVA. Such lumping shall be consistent from case to case within a model series.

10. Where per unit data is required by a dynamic model, all such data shall be provided in per unit on the generator or device nameplate MVA rating as given in the steady-state generator data record. This requirement also applies to excitation system and turbine-
governor models, the per unit data of which shall be provided on the nameplate MVA of the associated generator. The maximum and minimum power of cross compound units should be provided on the nameplate MVA of one machine in accordance with PSS®E model IEEEG1 conventions.

11. Exceptions will be approved by MMWG on a case by case basis and the reason for each exception will be documented in the SDDB.

**Miscellaneous Other (MINS) Dynamic models**

1. If a generator, transformer, or capacitor has in-service relay protection that operates in 10 seconds or less, then the relay models shall be submitted when available. Inverter-based generator resources shall have frequency and voltage protective relay models.

2. PSS®E Model Instance (MINS) values for “Miscellaneous Other” models should be a unique eight digit number. The first six digits should be the bus number at which the model is being applied. The last two digits should be a unique number designating a particular application of a “Miscellaneous Other” model at the bus. Under no circumstance shall a unique eight digit MINS number be repeated.

   MINS example: 59999900 VTGDCAT
   Bus number = 599999
   Unique identifier = 00
   Relay model = VTGDCAT

3. Unique MINS values are required for VTGDCAT/VTGTPAT, FRQDCAT/FRQTPAT, SAT2T, and SWCAPT relay models.

   **PSS®E Miscellaneous Other (MINS) Dynamic model types:**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VTGDCAT/VTGTPAT</td>
<td>Under/over voltage generator bus disconnection relay.</td>
</tr>
<tr>
<td></td>
<td>Under/over voltage generator trip relay.</td>
</tr>
<tr>
<td>FRQDCAT/FRQTPAT</td>
<td>Under/over frequency generator bus disconnection relay.</td>
</tr>
<tr>
<td></td>
<td>Under/over frequency generator trip relay.</td>
</tr>
<tr>
<td>SAT2T</td>
<td>Transformer saturation model.</td>
</tr>
<tr>
<td>SWCAPT</td>
<td>Switched capacitor bank model.</td>
</tr>
</tbody>
</table>

**PROCEDURE FOR INITIALIZATION AND NO-DISTURBANCE CHECKS OF LIBRARY DYNAMICS CASES**

Note: PSS®E activities relevant to the following steps are shown in brackets.

1. Create a converged load flow case with as few limit violations and questionable data items as possible.
   a. Solve the case after each set of major changes [FNSL, FDNS, SOLV, or MSLV] and save it to minimize rework if a change has unintended consequences. If all of the following constraints
are satisfied, convergence within tolerance, even from a flat start, should not take more than the default number of iterations. However, there is usually no reason to use a flat start if the case being updated was solved.

b. Generator checks using a list of all data to spot unrealistic, typically default, generator data values. [LIST, option 5] There is no checking activity listing only machines having suspect values of the following
   i. Machine MVA on the default base of 100. Although models will work if all load flow and dynamic model parameters are entered on this basis, limit checks will not work correctly.
   ii. Source impedance of 1.0 p.u. on machine MVA base. This value is substantially higher than normal for synchronous machines.
   iii. Source impedances equal to or less than zero. These will cause generator conversion to fail.
   iv. Real and/or reactive power limits of +9999 or –9999.

c. Checks which report abnormal values
   v. Branch flows exceeding normal ratings. [RATE or OLTL and OLTR]
   vi. Bus voltages below 0.95 p.u. except in the case of generator terminal voltage buses connected to the transmission bus by a step-up transformer with a tap ratio significantly off nominal. [VCHK]
   vii. Overloaded generators. [GEOL]. Note that this activity checks machine output against the machine MVA base, MBASE, not against PMAX, PMIN, QMAX, and QMIN.
   viii. Branches with extreme impedances or tap ratios [BRCH].
   Suggested options are:
   a) Small impedance. Note that very small impedances can be treated as zero impedance ties by selection of parameter THRSHZ and these will not be a problem.
   b) Negative reactance. These are typically found in Y representations of three winding transformers. Solution activity SOLV may not be used on cases containing such branches and MSLV may not be used if they are present at a Type 2 or 3 (generator) bus.
   c) Charging. Values exceeding the default upper check limit (5.0 p.u.) are normal on long EHV lines but others should be checked. Negative values are occasionally used for magnetizing impedance on transformers but this usage is not recognized in the PSS®E Program Operation Manual.
   d) Parallel transformers. Minor tap ratio differences may simply reflect field conditions, but differences exceeding one step should be checked to guard against inadvertent errors.
   e) High tap ratios.
   f) Low tap ratios.

d. Interactive checks: the user is asked to enter new value(s) for each exception, or hit “carriage return” for no change.
   i. Generators dispatched outside their real power limits [SCAL]. Scaling areas or zones should be used cautiously if generators having default PMAX (+9999) and PMIN (-9999) limits are present.
ii. Inconsistent targets at a bus whose voltage is controlled by two or more system elements: local generation, switched shunts, and voltage controlling transformers. [CNTB]. There is a tendency not to recognize different summer and winter operating strategies where appropriate.

iii. Questionable voltage or flow controlling transformer parameters. [TPCH]

iv. Buses in “islands” not containing a system swing bus. [TREE]. Note that there can be multiple islands each of which does contain a system swing bus, with DC links connecting them.

2. To confine the initialization to a subset of the original load flow, for instance the areas comprising one region, proceed as follows.
   a. Create a raw data file containing only the area(s) of interest. [RAWD, AREA]
   b. Read in the raw data file just created. [READ]
   c. If no system swing bus is in the area kept, change the type of a generator bus from 2 to 3 to make it the system swing bus. [CHNG]
   d. Locate any islands created by the subsetting operation and either connect or drop them. [TREE].
   e. Replace flows on tie lines severed by the subsetting operation with equivalent loads (positive for flows out, negative for flows in). [BGEN]

3. Net generation with load at any buses where a generator(s) exists for which no dynamic models are available. [GNET].

4. Convert the generators in the load flow [CONG], solve, [ORDR, FACT, TYSL] and save converted case. [SAVE]

5. From the dynamics entry point, read in the dynamic model data file [DYRE] (Load flow case must also be in memory.)
   a. Specify CONEC, CONET, and COMPIL files.
   b. It is highly desirable to include a SYSANG model in the DYRE file, although this makes it mandatory to recompile even if no user models are included. This model provides six monitoring output channels, which can be used to scan a no-disturbance simulation for stability without attempting to select individual machines to monitor.

6. Concatenate FLECS code for user models onto CONEC or CONET files.

7. Compile.


9. Restart from the dynamics entry point, this time using “user dynamics”.
   a. Read converted load flow [CASE].
   b. Read in the dynamic data file [DYRE]
   c. Specify channels to record appropriate states and variables as simulation outputs [CHAN]. Include SYSANG variables if this model was included in the dynamics data file as suggested above.
   d. Check consistency of dynamic models [DYCH, option 1].
   e. Initialize dynamic simulation [STRT]. The output of this activity may have several important parts and it is desirable to keep a log file for reference while debugging.
      i. Warning messages for
         a) Generators in the load flow for which there is no active machine model.
         b) Models, usually of excitation systems or governors, initialized out of limits.
         c) The number of iterations required to initialize the initial-conditions steady-state.
ii. A tabulation of conditions at each online machine
   a) Terminal voltage
   b) Exciter output voltage
   c) Real and reactive power output
   d) Power factor
   e) Machine angle in degrees
   f) Direct and quadrature axis currents on machine base.

iii. A diagnosis of initial conditions, either
   a) “Initial conditions check OK”, or
   b) A listing of suspect initial conditions generally states whose time derivative is not
      “small” (relative to the value of the state). These may be caused by inconsistencies
      between the real and reactive power scheduled for a unit by the load flow
      (including automatic changes in reactive power to hold bus voltage at a target
      level) or by parameter errors.

iv. For models flagged in steps i) through iii), consider using activity
    [DOCU] to identify parameters which may be causing problems.
    This activity will also give the automatically calculated values of
    exciter model parameters, which are derived if the corresponding
    parameters, as read in, are 0. Other warnings may indicate errors
    in the steady-state model.

f. Modify model parameters or the load flow as appropriate and repeat steps up to this point
   until there are no warning messages nor suspect initial conditions.

10. Record a snapshot [SNAP] of dynamic state values prior to application of any disturbance
    or simulation of any time period.

11. Simulate undisturbed operation [RUN] for at least 20 seconds. Printing the convergence
    monitor [RUN,CM] can indicate where problems are, but considerably increases the
    amount of output.

12. Stop simulation. Review output values in tabular and/or graphical form.

13. Validate exciter model response to a step change in set point. [ESTR] and [ERUN]. Field
    voltage and terminal voltage will be output for each exciter model and may be reviewed
    in tabular or graphical form. Satisfactory response is indicated if the terminal voltage
    settles to the specified value within a few seconds, if the field voltage is reasonable, and
    the response is free of
    a. Excessive overshoot
    b. Sustained oscillations
    c. High frequency noise (may be caused by using too long a simulation time step.)
    d. Unexpected discontinuities in the output variables or their derivatives (except IEEE Type 4
       “non-continuous” regulator models).

14. Validate governor model response to a step change. [GSTR] and [GRUN]. Mechanical
    power and speed deviation will be output for each shaft where a governor model is
    present and may be reviewed in tabular or graphical form. Models of cross-compound
    unit governors specify two machines so four output variables are used. Steam or
    combustion turbine unit governors may require up to 20 seconds to attain equilibrium,
    and hydro units even longer, even if they are well tuned. Satisfactory response is
    indicated if speed deviation settles to approximately (- K) = (-1 / R), mechanical power to
    (1-1/K) times the specified value, and the response variables are free of excessive
    overshoot or sustained oscillations.
Dynamic Data Format

PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E dyr file software. Dyre file submittals can be of changes to individual components from the existing dyre entries or of entire new representation of machines. Dynamic ready models are developed using the PSS®E software program. The data should be submitted via GlobalScape or email. Data submitted must be compatible with the PSS®E version currently specified by SPP.

Non-PSS®E Users
Dynamics data needs to be submitted in the form of a flat text file or dyre file compatible with Siemens PTI PSS®E software. Siemens PTI PSS®E Software contains dyre file models for most conventional machines, exciters, governors, SVCs, HVDC ties, wind resources, and solar resources. SPP Modeling staff will work with the responsible entity or its designee to translate operational test data into the appropriate dyre file format compatible with the PSS®E version currently specified by SPP.

Acceptable Dynamic Model Information
The PSS®E simulation software dynamic machine models may be used as long as they are included on the NERC List of Acceptable Models for Interconnection-Wide Modeling and not identified as unacceptable models on that list. The NERC acceptable dynamic model list can be found on the NERC SAMS website → SAMS Reference Materials → NERC Acceptable Model List.

Significant improvements to models may occur over time and models may become obsolete, not recommended, or unacceptable models. Unacceptable models might still be available in the PSS®E software; however, those models must be replaced with more suitable current acceptable models.

User-written dynamic models will only be allowed under the following conditions:
1. Technical basis as to why the user-written model should be used in place of the Siemens PTI PSS®E standard library model in consideration of a regional transmission system analysis
2. Dynamic model data is submitted in .dyr format
3. Dynamic model data is submitted in .lib or .dll format for compilation and linking purposes.
4. Documentation, including Block Diagram, in .pdf or .docx format
5. A written commitment from the Data Owner to SPP, as PC, indicating that user-written models will be converted to the applicable acceptable dynamic model within 18 months of being notified of request for conversion to an acceptable model by SPP or Transmission Planner.

MDWG developed a subset list of acceptable dynamic models based on the NERC acceptable dynamic model list and adheres to the guidance outlined in the MDWG Dynamic Models Guidelines document.

Dynamics Data Validation Requirements
1. All dynamics modeling data shall be screened according to the SDDB data screening checks.
2. All data items not passing these screening tests shall be resolved with the generator or
dynamic device owner and corrected.
3. All regional data submittals to the MMWG coordinator shall have previously undergone
satisfactory initialization and 20-second no-disturbance simulation checks for each
dynamics case to be developed. The procedures outlined in Section III.H* of this manual
(*yet to be written) may be applied for this purpose.

Guidelines

1. Dynamics data submittals containing typical data should include documentation which identifies
those models containing typical data. The CON conservation models, such as GENROA and
GENSAA, which essentially copy dynamics data from one unit to another, may be useful for this
purpose. When typical data is provided for existing devices, the additional documentation
should give the equipment manufacturer, nameplate MVA base and kV, and unit type (coal,
nuclear, combustion turbine, hydro, etc.).
2. The voltage dependency of loads should be represented as a mixture of constant impedance,
constant current, and constant power components (referred to as the ZIP model). The Regions
should provide parameters for representing loads via the PTI PSS®E CONL activity. These
parameters may be specified by area, zone, or bus. Other types of load modeling should be
provided to MMWG when it becomes evident that accurate representation of interregional
dynamic performance requires it.

Procedures for Submission of Dynamics Data to the MMWG Coordinator
Regional Coordinators have two options, described below, for submitting dynamics data to the
MMWG Coordinator.

DYNAMICS DATA UPDATES USING EXCEL TEMPLATE
Regional dynamics data updates are incremental to the dynamics data in the previous year
release of SDDB. Regional Coordinators should therefore verify that bus names and unit IDs in
SDDB are consistent with those in the MMWG steady-state to be made dynamics ready.
The table below describes the various types of updates and the required data and information
that should be provided on the Excel template and in a separate DYRE file.

<table>
<thead>
<tr>
<th>Type of Update</th>
<th>Template Entries</th>
<th>Complete DYRE format record</th>
<th>Examples / Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change one or more parameters of a</td>
<td>Bus name, unit ID, model</td>
<td></td>
<td>The voltage regulator gain is changed to the value determined by test.</td>
</tr>
<tr>
<td>dynamics model</td>
<td>name, parameter name, new value</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Add a new model to an existing unit</td>
<td>No</td>
<td>Yes</td>
<td>A stabilizer is being added to a unit which did not have one.</td>
</tr>
<tr>
<td>Delete a model</td>
<td>Bus name, unit ID, model name</td>
<td>No</td>
<td>A stabilizer is removed.</td>
</tr>
</tbody>
</table>
Replace a model with another model of the same equipment group

| Replace a model with another model of the same equipment group | Bus name, unit ID, model name for deleted model. | Yes for new model. | 1. A DC exciter is replaced by a static exciter. 2. A classical machine model is replaced by a detailed model. |
| Change bus name and/or unit ID for all models of an existing unit | Old and new names; old and new unit IDs | No | |
| Change bus number | No | No | Maintain the same name and unit ID and the model data will follow automatically. |
| Add dynamic models for a new generating unit | Bus name, unit ID, in service and out of service dates, MVA base, Zsource, RPM, unit type | Yes | Same requirements whether unit is at new or existing bus. |
| Remove a unit and all associated models | Bus name, unit ID | No | |

**COMPLETE SET OF DYNAMICS DATA**

The regional dynamics data must be in the format of a PSS®E DYRE file. The data must be compatible and consistent with the MMWG steady-state selected for the dynamics cases that are being developed. One file for all cases is preferable.

**System Dynamic Data Base and Dynamic Simulation Cases**

SPP Dynamic Base Case Models are available to all SPP members. SPP and its members, by participating in MMWG dynamics database (SDDB) and dynamics simulation case development, grant authority to the other participating Regions, to receive and use the SDDB and dynamics simulation cases. Regional members may send dynamics simulation cases or dynamics data to third parties provided that the third party executes a SPP confidentiality/non-disclosure agreement. The MMWG Dynamics Database (SDDB) remains the property of and is for the sole use of the MMWG participating Regions of NERC and their members.
SECTION 5: SHORT CIRCUIT DATA REQUIREMENTS

The Short Circuit models are developed using data gathered through the SPP database Model On Demand (MOD) in conjunction with the Engineering Data Submission Tool (EDST). MOD data is divided into three parts: a Base Case, Projects, and Profiles (Bus, Loads, Generation, and Device Control). Modeling updates for transmission system topology can be made by submitting a Project to MOD. Additional required data is submitted through the EDST which is identified in the data preparation section of this manual.

SPP MDWG Short Circuit Models are published according to the approved schedule.

TRANSMITTED DATA FILE EXAMPLES (Refer to MOD Procedure Manual)

PTI-PSS®E SHORT CIRCUIT DATA FORMAT

The SPP Short Circuit data is included in MOD Base Case (Network) and Project data and is submitted/updated in alignment with the MDWG Powerflow model build. The sequence data is comprised of zero sequence data and, specific to generators the positive and negative sequence data must also be provided. Short circuit data that is missing in the MOD Base Case must be entered in MOD via a MOD Project with the Project Type of Network and Project Status of Update, additionally the associated sequence file must be attached to the project file. Missing Project sequence data must be updated by applying a sequence file to the Project in MOD. All Short-circuit applicable MOD projects must have updated sequence data attached with the MOD project.

The PC (SPP) prior to presenting short circuit models to the MDWG for approval shall verify that all submitted member data has been correctly added to the short circuit models. The short circuit models shall be checked for errors and validated as usable by the PC. Any errors in the sequence data shall be brought to the attention of the Data Submitter. The usability checks shall include the PC performing data checks for missing sequence data and testing of models. The test of the models shall consist of fault analysis for three-phase, single-line-to-ground, and double-line-to-ground. The testing of the models is to ensure the models are ready for fault analysis by the SPP membership and absent of modeling errors.

For retired generators, GSUs are kept in service if there is an interrupting device on the low side of the GSU in order to produce accurate short circuit results.

MUTUAL IMPEDANCE

Mutual coupling exists between two or more transmission lines that are routed in parallel for a substantial distance due to the magnetic fields and flux linkage between the parallel conductors. For these configurations, a fault on one line can induce a large zero-sequence current (i.e. ground current) in the un-faulted parallel line and may lead to inappropriate tripping of the un-faulted line. Zero-sequence current is only present during ground faults, so the consideration of mutual coupling effects only applies to the derivation of ground fault protective element settings. Mutual impedance can be constructive or destructive; in other words, it may increase or decrease the zero-sequence
fault current. It is important that the mutual impedances between all line pairs be calculated and included when developing the system model.

A best practice approach for identifying and submitting the correct mutual impedance data is by synchronizing all short circuit databases across the different software platforms (CAPE, ASPEN, PSS®E, etc.) in each respective company’s footprint. In synchronizing the short-circuit data across the different software platforms, verification of which database is the primary source for the short-circuit data is imperative. Typically the approach for determining when mutual impedance data is required in the PSS®E models can be identified by checking when mutual impedance data is modeled and updated in a company’s primary database.

Mutual impedance data shall be submitted by attaching it to the applicable MOD project.

**Member submitted sequence via an IDEV file applied to a model will not be included in the next published model (Pass N or Final).** The reason that sequence data is not carried over from one model set to the next model set is that sequence data is exported from MOD. Post MOD model processing IDEV files are not applied to the next model set; therefore, a MOD project which includes the sequence data must be submitted to MOD and accepted before it is included in the next MOD exported model.

Short Circuit models are developed annually using a subset of the MDWG Powerflow models. **All base MDWG steady-state models will include sequence data (including applicable mutual line impedance data) for the SPP footprint.** The following 3 versions of short circuit models will be built:

1. MDWG steady-state base model
2. MDWG steady-state with PSS®E Classical assumptions
3. Maximum Fault case

The Base MDWG Short Circuit models are built by performing the following steps:

1. Extract the SPP RAW and SEQ data with ties from the final MDWG steady-state model
2. Extract the first tier company's RAW and SEQ data without ties from the final SERC Short Circuit model built by the Short Circuit Database Working Group (SCDWG)
3. Merge the two data sets together

The Classical assumptions MDWG Short Circuit Models are built by performing the following step:

1. Apply Classical assumptions to the Base MDWG Short Circuit model as described in the PSS®E Program Operation Manual

Maximum Fault cases are built by performing the following steps:

1. Place in-service (Apply a status of ‘1’) all SPP planned and available existing generation and transmission facilities to the Base MDWG Short Circuit model
2. Apply Classical assumptions

All transformers shall have a Vector Group and corresponding Connection Code in PSS®E 33+ format. Prior to presenting the short-circuit models to MDWG, SPP staff will conduct a preliminary

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24 **NERC Lesson Learned: Consideration of the Effects of Mutual Coupling when Setting Ground Instantaneous Overcurrent Elements**
analysis of three phase balanced and unbalanced faults for the purpose of validating the integrity of the modeled sequence information prior to finalization.

Other information requested by the PC or TP – Information which the PC or TP deems necessary for modeling purposes can be requested from Data Owners/Data Submitters.
SECTION 6: DEFINITIONS

These definitions are defined for purposes of model building and are not applicable outside the scope of the MDWG Model Building Procedure Manual.

**Auxiliary or Station Service load** – Real and reactive power necessary to operate a generating unit or other load that is directly related to the production of energy.

**Coincident Peak (Model)** – SPP coincident peak equals the highest demand including transmission losses for energy measured over a one clock hour period during the defined season.

**Demand Side Management** – Demand Side Management consists of activities or programs that an entity invokes to achieve a reduction in Demand and may consist of controllable and/or non-controllable systems.

**Data Owner**$^{25}$ – The entity that is responsible for ensuring the accuracy and timely submission of data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Data Submitter**$^{1}$ – The entity that is responsible for submitting data to the SPP, as Planning Coordinator, in accordance with the SPP Model Development Procedure Manual.

**Distributed Energy Resources** – Power resources on the distribution system that can be aggregated together to provide power to meet Peak Demand.

**Engineering Data Submission Tool (EDST)** – A web-based application for storing, coordinating, and facilitating data between Data Submitters and SPP.

**Equivalencing** – The general technique that substitutes power system equipment with a simplified representation that closely approximates the characteristics and behavior of the actual equipment.

**Exploratory Generation** – Generation resources that have a strong likelihood or commitment to be implemented, but have not completed the Generation Interconnection process. These generation resources may be added to the appropriate models for shortfall purposes only.

**Interchange (Model)** – Energy transfers that cross Balancing Authority boundaries. The algebraic sum of purchases and sales for a modeling area where a positive value is considered is a power export and a negative value is considered a power import.

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$^{25}$ Not a NERC functional entity
Model Area – The collection of model objects comprising an entity’s network and uniquely numbered in PSS®E.

Peak Demand – The highest demand including transmission losses for energy measured over a one clock hour period.26

PSS®E – Siemens PTI’s Power System Simulator for Engineering software tool for electrical transmission analysis used to model the SPP transmission system.

PSS®E MOD – A distributed web-based application for power transmission planning model management and provision of study models using a single consolidated data repository.

PSS®MOD File Builder – A stand-alone Siemens tool that is designed to help PSS®E users capture model changes in the form of PSS®MOD Modeling projects by comparing PSS®E models.

Transaction (Model) – A modeled purchase and/or sale of power.

Non-scalable load – Load that does not conform to the daily load duration curve.

On-Peak (Model) – Those hours or other periods typically considered periods of higher electrical demand.

Off-Peak (Model) – Those hours or other periods typically considered periods of lower electrical demand.

Regulating device – Equipment that manipulates power system parameters towards a setpoint or setpoints (e.g. a static reactive device maintaining system voltage).

Shortfall – Occurs when an entity does not have enough dispatchable generation to serve the entity’s load.

Tie Line (Model) – A circuit connecting two Model Areas.

26 Attachment AA Resource Adequacy Section 2
SECTION 7: APPENDIX I
MASTER TIE LINE FILE DATA FIELDS

Branch Data Fields

In Service Date,
Out Service Date,
From Region Name,
From Area#, 
From Area Name,
From Bus#, 
From Bus Name,
From Bus kV,
To Region Name,
To Area#, 
To Area Name,
To Bus#, 
To Bus Name,
To Bus kV,
Metered End (F,T),
CKT,
R,
X,
B,
Summer Rating A,
Summer Rating B,
Summer Rating C,
Winter Rating A,
Winter Rating B,
Winter Rating C,
G1 (pu),
B1 (pu),
Gj (pu),
Bj (pu),
STATUS (0,1),
LEN (mi),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4
Two Winding Transformer Data Fields

In Service Date,
Out Service Date,
From Bus Region Name,
From Bus Area#,
From Bus Area Name,
From Bus Number,
From Bus Name,
From Bus kV,
To Bus Region Name,
To Bus Area#,
To Bus Area Name,
To Bus Number,
To Bus Name,
To Bus kV,
Tapped Side,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
Metered Side,
NAME,
STATUS (0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
Two Winding Transformer Data Fields - continued
COD1,
Volt Control Bus Region Name,
Volt Control Bus Area Number,
Volt Control Bus Area Name,
Volt Control Bus Number (CONT1),
Volt Control Bus Name,
Volt Control Bus kV,
RMA1,
RMI1,
VMA1,
VMI1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2
Three Winding Transformer Data Fields

In Service Date,
Out Service Date,
Winding 1 Region Name,
Winding 1 Area#,
Winding 1 Area Name,
Winding 1 Bus #,
Winding 1 Bus Name,
Winding 1 Bus kV,
Winding 2 Region Name,
Winding 2 Area#,
Winding 2 Area Name,
Winding 2 Bus #,
Winding 2 Bus Name,
Winding 2 Bus kV,
Winding 3 Region Name,
Winding 3 Area#,
Winding 3 Area Name,
Winding 3 Bus #,
Winding 3 Bus Name,
Winding 3 Bus kV,
CKT,
CW,
CZ,
CM,
MAG1,
MAG2,
NMETR(1,2,3),
NAME,
STATUS(0,1),
Owner 1,
Fraction 1,
Owner 2,
Fraction 2,
Owner 3,
Fraction 3,
Owner 4,
Fraction 4,
R1-2,
X1-2,
SBase1-2,
R2-3,
X2-3,
SBASE2-3,
R3-1,
Three Winding Transformer Data Fields - continued

X3-1,
SBASE3-1,
VMSTAR,
ANSTAR,
WindV1,
NomV1,
Ang1,
Summer Rating A1,
Summer Rating B1,
Summer Rating C1,
Winter Rating A1,
Winter Rating B1,
Winter Rating C1,
COD1,
Control Bus 1 Region,
Control Bus 1 Area Number,
Control Bus 1 Area Name,
Control Bus #(CONT1),
Control Bus Name,
Control Bus KV,
RMA1,
RMI1,
VMA1,
VMI1,
NTP1,
TAB1,
CR1,
CX1,
WindV2,
NomV2,
Ang2,
Summer Rating A2,
Summer Rating B2,
Summer Rating C2,
Winter Rating A2,
Winter Rating B2,
Winter Rating C2,
COD2,
Control Bus 2 Region,
Control Bus 2 Area Number,
Control Bus 2 Area Name,
CONT2,
Control Bus 2 Name,
Control Bus 2 KV,
RMA2,
Three Winding Transformer Data Fields - continued
  RMI2,
  VMA2,
  VMI2,
  NTP2,
  TAB2,
  CR2,
  CX2,
  WindV3,
  NomV3,
  Ang3,
  Summer Rating A3,
  Summer Rating B3,
  Summer Rating C3,
  Winter Rating A3,
  Winter Rating B3,
  Winter Rating C3,
  COD3,
  Control Bus 3 Region,
  Control Bus 3 Area Number,
  Control Bus 3 Area Name,
  CONT3,
  Control Bus 3 Name,
  Control Bus 3 KV,
  RMA3,
  RMI3,
  VMA3,
  VMI3,
  NTP3,
  TAB3,
  CR3,
  CX3
Two Terminal DC Tie Data Fields
In Service Date,
Out Service Date,
I,
MDC,
RDC,
SETVL,
VSCHD,
VCMOD (1,0),
RCOMP,
DELTI,
METER (RJ),
DCVMIN,
CCCITMX,
CCCACC,
IPR REGION NAME,
IPR AREA#,
IPR AREA NAME,
IPR Bus#,
IPR Bus NAME,
IPR BUS kV,
NBR,
ALFMX,
ALFMN,
RCR,
XCR,
EBASR,
TRR,
TAPR,
TMXR,
TMNR,
STPR,
ICR REGION NAME,
ICR AREA#,
ICR AREA NAME,
ICR BUS#,
ICR BUS NAME,
ICR BUS kV,
IFR REGION NAME,
IFR AREA#,
IFR AREA NAME,
IFR BUS#,
IFR BUS NAME,
IFR BUS kV,
ITR REGION NAME,
ITR AREA#,
Two Terminal DC Tie Data Fields
ITF AREA NAME,
ITR BUS#, 
ITR BUS NAME, 
ITR BUS KV, 
IDR, 
XCAPR, 
IPI REGION NAME, 
IPI AREA#, 
IPI AREA NAME, 
IPI Bus#, 
IPI BUS NAME, 
IPI BUS Kv, 
NBI, 
GAMMX, 
GAMMN, 
RCI, 
XCI, 
EBASI, 
TRI, 
TAPI, 
TMXI, 
TMNI, 
STPI, 
ICI REGION NAME, 
ICI AREA#, 
ICI AREA NAME, 
ICI BUS#, 
ICI BUS NAME, 
ICI BUS Kv, 
IFI REGION NAME, 
IFI AREA#, 
IFI AREA NAME, 
IFI BUS#, 
IFI BUS NAME, 
IFI BUS KV, 
ITI REGION NAME, 
ITI AREA#, 
ITI AREA NAME, 
ITI BUS#, 
ITI BUS NAME, 
ITI BUS KV, 
IDI, 
XCAPI 

Notes: (1) The data formats must be compatible with PSS®E input requirements. 
(2) The in-service and out-of-service dates will be expressed as mm/dd/yyyy.
SPP Model Development Procedure Manual

SECTION 8: APPENDIX II
UTILIZED IMPEDANCE CORRECTION TABLES
Table
Number

Tap or
Angle

1
Factor

Tap or
Angle

2
Factor

Tap or
Angle

3
Factor

Tap or
Angle

4
Factor

Tap or
Angle

5
Factor

Tap or
Angle

6
Factor

Tap or
Angle

7
Factor

Tap or
Angle

8
Factor

Tap or
Angle

9
Factor

Tap or
Angle

10
Factor

Tap or
Angle

11
Factor

1

-60

1

-36

0.358

-24.4

0.192

-12.4

0.054

-8.3

0.024

0

0.01

8.3

0.024

12.4

0.054

24.4

0.192

36

0.358

60

1

2

-70

1

-43

0.78

-32

0.85

0

0.5

32

0.85

43

0.78

70

1

0

0

0

0

0

0

0

0

3

-180

1

-150

0.5

0

0.5

150

0.5

180

1

0

0

0

0

0

0

0

0

0

0

0

0

4

-152

1

-121.5

0.625

-85.4

0.372

-42.2

0.217

0

0.157

42.2

0.217

85.4

0.372

121.5

0.625

152

1

0

0

0

0

8

-40

1.848

-30

1.468

0

1

30

1.538

40

1.83

0

0

0

0

0

0

0

0

0

0

0

0

10

-25

1.995

0

1

25

1.995

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

11

-25

1.995

0

1

25

1.995

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

12

-40

1.66

-29.5

1.331

-25.1

1.228

-20.6

1.145

0

1

20.6

1.145

25.1

1.228

29.5

1.331

40.1

1.66

0

0

0

0

13

-40

1.849

-30

1.402

-20

1.196

-10

1.045

0

1

10

1.045

20

1.161

30

1.366

40

1.741

0

0

0

0

16

-30

1.913

0

1

30

1.913

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

17

-47

6.34

-41.7

5.44

-33.3

4

-27.5

3.06

-18.5

2

0

1

18.5

1.76

27.5

3.278

33.3

3.643

41.7

5.25

47

1

18

-40

2.31

0

1

40

2.31

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

19

-40

7.35

-30

4.85

-20

2.9

-10

1.6

0

1

10

1.6

20

2.9

30

4.85

40

7.35

0

0

0

0

20

0.937

1.641

1

1

1.03

1.02

1.1

1.427

0

0

0

0

0

0

0

0

0

0

0

0

0

0

21

0.889

0.575

1.04

1

1.2

2.89

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

22

0.8

1.563

0.85

1.384

0.9

1.235

0.95

1.108

1

1

1.05

0.907

1.1

0.826

1.15

0.756

1.2

0.694

1.25

0.64

1.3

1

23

-10

1

5

0.655

20

1.449

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

25

-60

9.2

-46.38

4.69

-32.3

1.87

-20

1

0

1

18

1

32.3

3

46.38

5.54

60

9.2

0

0

0

0

31

-15

2.076

0

1

15

2.076

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

32

-15

1.62

0

1

15

1.62

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

33

-5.7

2.061

0

1

5.7

2.061

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

34

-10

1.782

0

1

10

1.782

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

35

-30

1.65

0

1

30

1.65

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

37

-15

2.076

0

1

15

2.076

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

0

40

-40

1

-35

0.75

-25

0.6

-12.5

0.55

-7.5

0.52

0

0.5

7.5

0.52

12.5

0.55

25

0.6

35

0.75

40

1

42

-42.5

1.784

-32.6

1.497

-22

1.26

-11.1

1.07

0

1

11.1

1.05

22

1.193

32.6

1.443

42.5

1.782

0

0

0

0

44

-52.9

1.9024

-43.6

1.6768

-33.7

1.4512

-23.2

1.2256

-12.3

1

-1.2

1.1385

9.9

1.2769

20.9

1.4154

31.4

1.5539

0

0

0

0

80


SECTION 9: APPENDIX III
DESIGNATING MOD-032-1 DATA SUBMITTAL ASSIGNMENT

See Page Below
Letter of Notice  
Designating MOD-032-1 Data Submittal Assignment  

On this _____ day of __________, 20____, __________________ and __________________, provide notice to Southwest Power Pool, Inc. (SPP) of the following: 

On ___________, 20__, ________________, Data Owner, and ________________, Data Submitter, entered into an agreement through which ________________ has agreed to submit on behalf of __________________ the (select one):  

☐ information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2.  

☐ following information required to be provided to SPP as its Planning Coordinator pursuant to NERC Reliability Standard MOD-032-1, R2: 

__________________________________________________________________________________________________________________  
__________________________________________________________________________________________________________________  
__________________________________________________________________________________________________________________  

The accuracy of the data is the responsibility of the Data Owner. This notice does not shift the compliance obligation from the Data Owner to the Data Submitter. The MOD-032 data to be submitted is set forth in MOD-032-1 Attachment 1. The schedule to submit data shall be set forth in the SPP modeling data requests and the then-effective SPP MOD-032 Model Development Procedure Manual data requirements and reporting procedures.  

The above designation will remain in effect pursuant to this notice until revoked by either the Data Owner or the Data Submitter in writing to SPP at SPPEngineeringModeling@spp.org. 

On behalf of DATA OWNER:    SPP hereby acknowledges receipt of this notice.  
By: ______________________________    By: ______________________________  
Printed Name: _____________________   Printed Name: _____________________  
Title: _____________________________   Title: _____________________________  
Date: _________________     Date: _________________  

On behalf of DATA SUBMITTER:  
By: ______________________________  
Printed Name: _____________________  
Title: _____________________________  
Date: _________________
SECTION 10: APPENDIX IV SPP MODEL ON DEMAND (MOD) MATRIX
<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Status</th>
<th>Description</th>
<th>Notes</th>
<th>Applied to this Model Set</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPP-approved Transmission System Upgrade</td>
<td>Must have an NTC for: 1) transmission service request(s); 2) transmission changes originating from the integrated transmission planning (ITP) process; 3) transmission changes originating from the Balanced Portfolio process; 4) transmission changes directed by the high priority study process; 5) transmission changes associated with Sponsored Upgrades.</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD. Projects associated with adding or removing components interconnected to the SPP Transmission System in accordance with SPP OATT Attachment V and AQ processes, are submitted separately under the &quot;Interconnection Agreement&quot; or &quot;Attachment AQ Load&quot; MOD Type.</td>
<td>MDWG ITP TS GI Special Study</td>
</tr>
<tr>
<td>Planned Transmission System Change</td>
<td>For Material Planned System Changes, Data Submitters shall submit an RMS ticket to notify SPP. An expected change to the SPP Transmission System that does not yet have or does not require an NTC, including: 1) transmission changes budgeted for or planned by the TO; 2) transmission changes budgeted for by a Transmission Customer or other entity; 3) transmission changes resulting from an emergency (e.g., unplanned equipment failure); 4) transmission, load, or generation changes that otherwise have a strong likelihood or commitment to implement (e.g., load change not yet approved by Attachment AQ, a GI with an IA but on suspension, a GI without an IA, etc.).</td>
<td>Acknowledged</td>
<td>X X X X X</td>
<td>The status for this MOD type will only be changed to &quot;Acknowledged&quot; by Data Submitters after receiving a notification from SPP for inclusion in the model sets.</td>
<td>MDWG ITP TS GI Special Study</td>
</tr>
<tr>
<td>Attachment AG</td>
<td>Changes to load and/or delivery points approved in accordance with Attachment AG, including any transmission changes associated with the Attachment AG project (e.g., equipment upgrade, changes to normally-open/closed topology).</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Projects with this status will not be reviewed by SPP. Speculative projects are not to include speculative changes to the SPP Transmission System. Changes to the SPP Transmission System included in the MOD shall be associated with the approved Attachment AG local modification.</td>
<td>MDWG ITP TS GI Special Study</td>
</tr>
<tr>
<td>Generation Interconnection</td>
<td>Additions or changes to generating units, including any transmission changes associated with the Generation Interconnection Service project(s) that: 1) have an executed Interconnection Agreement (IA) or executed Interim Generator Interconnection Agreement (IGA), and 2) are not suspended.</td>
<td>Approved</td>
<td>X X X X X</td>
<td>Projects with this status will be immediately committed to the MOD base case upon review.</td>
<td>MDWG ITP TS GI Special Study</td>
</tr>
<tr>
<td>Network Status</td>
<td>Changes to the existing SPP Transmission System network topological status only (both placed out-of-service or returned to service).</td>
<td>Update</td>
<td>X X X X X</td>
<td>Projects with this status will not be applied to any models except to those models submitted to MMWG-C.</td>
<td>MDWG ITP TS GI Special Study</td>
</tr>
<tr>
<td>Modeling Correction</td>
<td>Changes to the transmission model necessary to correct or update the existing transmission model represented by the MOD network data.</td>
<td>Update</td>
<td>X X X X X</td>
<td>Projects with this status will not be applied to any models except to those models submitted to MMWG-C.</td>
<td>MDWG ITP TS GI Special Study</td>
</tr>
<tr>
<td>System Intact Alteration</td>
<td>Changes to the transmission model necessary to correct basecase system intact voltage (e.g., to conform to MMWG/SA voltage criteria), thermal criteria violations, or other basecase condition modifications (e.g., addition of an exploratory generating unit which provided reserve for shortfalls).</td>
<td>Update</td>
<td>X X X X X</td>
<td>Projects with this status will not be applied to any models except to those models submitted to MMWG-C.</td>
<td>MDWG ITP TS GI Special Study</td>
</tr>
</tbody>
</table>
GEOMAGNETIC DISTURBANCE MODELING DATA

Additional modeling data is necessary to supplement the MDWG steady-state models to support geomagnetic disturbance (GMD) analysis. The SPP GMD Model Set combines GMD-related system information (described below) with the MDWG AC-equivalent representation of the SPP transmission system. This composite of modeling data yields a DC-equivalent representation used to calculate geomagnetically-induced current (GIC) flows. These GIC magnitudes can then be applied to the MDWG AC-equivalent model to yield steady-state effects to System voltages and transformer MVAR losses. Appropriate simulations of GMD effects to the BES cannot be achieved without the incorporation of the following modeling information:

Substation Data
Substation modeling data encompasses geographical information related to power system topological information, as represented by the bus-branch model.

Bus Number (Planning Model): This is the actual bus from the Planning Model. This bus will be associated with a substation on the Substations sheet.

Substation Bus Number (Planning Model): Choose one bus to serve as the substation reference. In other words, the bus number annotated in this field will serve as the geographic reference for the entire substation. The recommendation is for the model Data Submitter to pick the highest voltage bus in a station to serve as this reference.

Substation DC Grounding Resistance (Ohms): This can be a measured, calculated, or assumed value for the grounding resistance in Ohms. Caution: do not convert this grounding resistance to per unit Ohms; retain the actual Ohmic quantity. In the unlikely event that a substation/switchyard is ungrounded, the model Data Submitter may enter "-1" here, not zero. Measured values come from ground grid testing, while calculated values are derived from detailed design modeling. When a substation is commissioned or periodic maintenance is performed, grounding integrity or ground grid data is typically collected.

Grounding Resistance (Method): This field indicates how the grounding resistance information was obtained.

Geographic Latitude (decimal degrees): This latitude will be used for all busses assigned to this station on the "Busses" sheet. Given that the entire SPP footprint is in the Northern Hemisphere, only positive decimal degree values are acceptable for latitude.
Geographic Longitude (decimal degrees): This longitude will be used for all busses assigned to this station on the "Busses" sheet. Caution: longitudes to the west of the Prime Meridian are between 0 and -180°. Given that the entire SPP footprint falls between the 85th west meridian and the 115th west meridian, only negative decimal degree values are acceptable for longitude.

Earth Model (Name): This field assigns the one-dimension earth conductivity model to the geographical location of the substation reference bus. The earth model is based upon the standard earth conductivity models developed by the United States Geological Survey (USGS). The following table shows the cross-reference between the USGS reference and the software code that should be placed in the “Earth Model (Name)” field. On the “1D Earth Model Reference” sheet, a tool is provided to assist in determining the proper earth model by latitude and longitude.

<table>
<thead>
<tr>
<th>USGS Earth Conductivity Model</th>
<th>Equivalent to:</th>
<th>Siemens/PTI software code (enter into the “Earth Model Name” field)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AK-1A</td>
<td></td>
<td>AK1A</td>
<td>Adirondack Mountains-1A</td>
</tr>
<tr>
<td>AK-1 B</td>
<td></td>
<td>AK1B</td>
<td>Adirondack Mountains-1B</td>
</tr>
<tr>
<td>AP-1</td>
<td></td>
<td>AP1</td>
<td>Appalachian Plateaus</td>
</tr>
<tr>
<td>AP-2</td>
<td></td>
<td>AP2</td>
<td>Northern Appalachian Plateaus</td>
</tr>
<tr>
<td>ATLANTIC</td>
<td></td>
<td>ATLANTIC</td>
<td>Northeastern Atlantic Coast, Nova Scotia</td>
</tr>
<tr>
<td>BC</td>
<td></td>
<td>BC</td>
<td>British Columbia (BC)</td>
</tr>
<tr>
<td>BR-1</td>
<td></td>
<td>BR1</td>
<td>Northwest Basin and Range</td>
</tr>
<tr>
<td>CL-1</td>
<td></td>
<td>CL1</td>
<td>Colorado Plateau</td>
</tr>
<tr>
<td>CO-1</td>
<td></td>
<td>CO1</td>
<td>Columbia Plateau</td>
</tr>
<tr>
<td>CP-1</td>
<td></td>
<td>CP1</td>
<td>Coastal Plain (South Carolina)</td>
</tr>
<tr>
<td>CP-2</td>
<td></td>
<td>CP2</td>
<td>Coastal Plain (Georgia)</td>
</tr>
<tr>
<td>CS-1</td>
<td></td>
<td>CS1</td>
<td>Cascade-Sierra Mountains</td>
</tr>
<tr>
<td>FL-1</td>
<td></td>
<td>none</td>
<td>Florida</td>
</tr>
<tr>
<td>IP-1</td>
<td></td>
<td>IP1</td>
<td>Interior Plains (North Dakota)</td>
</tr>
<tr>
<td>IP-2</td>
<td></td>
<td>IP2</td>
<td>Interior Plains</td>
</tr>
<tr>
<td>IP-3</td>
<td></td>
<td>IP3</td>
<td>Interior Plains (Michigan)</td>
</tr>
<tr>
<td>IP-4</td>
<td></td>
<td>IP4</td>
<td>Interior Plains (Great Plains)</td>
</tr>
<tr>
<td>MID-ATL</td>
<td></td>
<td>PT-1</td>
<td>Mid-Atlantic</td>
</tr>
<tr>
<td>NE-1</td>
<td></td>
<td>NE1</td>
<td>New England</td>
</tr>
<tr>
<td>USGS Earth Conductivity Model</td>
<td>Equivalent to:</td>
<td>Siemens/PTI software code (enter into the “Earth Model Name” field)</td>
<td>Description</td>
</tr>
<tr>
<td>------------------------------</td>
<td>----------------</td>
<td>-------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>OZARK</td>
<td>CP-2</td>
<td>CP-2</td>
<td>Ozarks</td>
</tr>
<tr>
<td>PB-1</td>
<td>PB1</td>
<td></td>
<td>Pacific Border (Willamette Valley)</td>
</tr>
<tr>
<td>PB-2</td>
<td>PB2</td>
<td></td>
<td>Pacific Border (Puget Lowlands)</td>
</tr>
<tr>
<td>PRAIRIES</td>
<td>PRARIES</td>
<td></td>
<td>Alberta (AB), Saskatchewan (SK), Manitoba (MB)</td>
</tr>
<tr>
<td>PT-1</td>
<td>PT1</td>
<td></td>
<td>Piedmont</td>
</tr>
<tr>
<td>RM</td>
<td>CL-1</td>
<td>CL-1</td>
<td>Rocky Mountain</td>
</tr>
<tr>
<td>SD</td>
<td>PB-1</td>
<td>SHIELD</td>
<td>Ontario (ON), Quebec (QC)</td>
</tr>
<tr>
<td>SL-1</td>
<td></td>
<td>SL1</td>
<td>St. Lawrence Lowlands</td>
</tr>
<tr>
<td>SU-1</td>
<td></td>
<td>SU1</td>
<td>Superior Upland</td>
</tr>
</tbody>
</table>

**Transformers**

The Transformers sheet is intended to collect all of the information necessary to properly determine the magnitude of GIC that will arise within a given transformer. It is important to note that transformer winding resistance data collected from transformer specification sheets or test reports may represent the total resistance of the three phases combined.

While well known to model Data Submitters, the convention for MDWG model data is consistent with most load flow software that requires data be submitted per phase. Therefore, any combined three-phase transformer winding resistance data must be divided by three prior to submitting quantities. Similarly, when DC resistances of transformer windings are unknown (estimated values should only be used when data are unavailable), a reasonable assumption is to substitute actual data with 50% of the per phase copper loss resistance. It is noted that total copper loss resistance may be converted to per phase by dividing by three, and all values should be entered as Ohms, not in per unit base. For example, transformer test reports typically report the total copper loss of a transformer, derived from a short-circuit test27, either as a total copper loss power [W] or as the total winding resistance [ohms] calculated from the total copper loss power. In either case, these quantities represent the total copper loss effects of three windings combined and must be divided by three to properly reflect the per phase resistance. The model Data Submitter is expected to provide the following data:

**Core Type**: This indicates the number of cores in transformer core design and is used to calculate transformer reactive power loss from GIC flowing in its winding. This field is only used by the software when a K-factor quantity is not specified by the model Data Submitter for the transformer.

---

27 Also known as a transformer impedance test, a typical transformer short-circuit test is performed by shorting the low-voltage winding and increasing the high-voltage winding voltage until transformer rated current is observed in the high-voltage winding. This test recognizes that core loss is negligible, yielding the resistive losses in the primary winding circuit.
In other words, if you know the K-factor for the transformer (or have a better assumption), enter the quantity in the "GIC Reactive Loss Factor (K-factor)" field and it diminishes the importance of the "Core Type" field. Otherwise, the values for this field are limited to:

<table>
<thead>
<tr>
<th>Code</th>
<th>Core Design Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Three-phase shell configuration</td>
</tr>
<tr>
<td>0</td>
<td>Unknown core design</td>
</tr>
<tr>
<td>1</td>
<td>Three separate single phase cores design</td>
</tr>
<tr>
<td>3</td>
<td>Three phase, 3-legged core configuration</td>
</tr>
<tr>
<td>5</td>
<td>Three phase, 5-legged core configuration</td>
</tr>
<tr>
<td>7</td>
<td>Three phase, 7-legged core configuration</td>
</tr>
</tbody>
</table>

If the core configuration is unknown, stating as such in the Core Type field is acceptable. When this is done, the software will make an assumption for K-factor based upon the voltage level of the highest winding voltage of that transformer. All transformers in the SPP MDWG model series are expected to have vector groups defined, so that T-modeling of transformers in the DC network is permitted.

**Connection Code (CC):** This is the field for the Data Submitter to update the Connection Code shown in the Existing Connection Code (CC) field, if warranted. This field is included because experience has shown that prior model-building efforts may not have focused on this data, but it is critical to GIC modeling. It is suggested that the model Data Submitter review vector group and winding order to ensure proper CC submittal.

**Vector Group:** This is key data required to properly model the grounding characteristics of a transformer. While potentially misleading, most load flow software packages embed the transformer per phase winding configuration information under short-circuit data category. The confusing aspect is that winding configuration is meaningful in situations other than under short-circuit conditions; for example, with GIC that arise from GMD. As a reminder, the Connection Code data contained within the load flow model representation embodies concepts of the transformer core type, the vector group (phase differences between windings, standardized with clock notation indicating phase displacement), and physical conductor orientation.

**GIC Reactive Loss Factor (K-factor):** The K-factor is an important aggregated assumption that helps formulate the transformer sensitivity to half-cycle saturation that arises from the contribution of GIC. In other words, the K-factor indicates a measure of increased reactive power losses in the transformer when subjected to GICs. The units of K-factor are MVAR per Ampere; the larger the K-factor the larger expected reactive power losses in the transformer. K-factor is used to calculate additional transformer reactive power losses according to:

\[ Q_{loss} = \text{Effective GIC Winding Current} \times K-\text{Factor}. \]
There is much debate in industry about how to measure, calculate, and assume values for K-factor. In general, if a K-factor is not specified on a transformer data sheet or in test reports, the following table annotates appropriate assumed values. It is noted that the following assumptions for K-factor are consistent with those integrated into the Siemens/PTI software:

<table>
<thead>
<tr>
<th>Core Type Code</th>
<th>Highest Winding kV</th>
<th>K-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>Any</td>
<td>0.33</td>
</tr>
<tr>
<td>0</td>
<td>&lt;=200 kV</td>
<td>0.6</td>
</tr>
<tr>
<td>0</td>
<td>&gt; 200 kV, &lt;= 400 kV</td>
<td>0.6</td>
</tr>
<tr>
<td>0</td>
<td>&gt; 400 kV</td>
<td>1.1</td>
</tr>
<tr>
<td>1</td>
<td>Any</td>
<td>1.18</td>
</tr>
<tr>
<td>3</td>
<td>Any</td>
<td>0.29</td>
</tr>
<tr>
<td>5</td>
<td>Any</td>
<td>0.66</td>
</tr>
<tr>
<td>7</td>
<td>Any</td>
<td>0.66</td>
</tr>
</tbody>
</table>

**DC Resistance of From, To, and Tertiary Windings (Ohms/Phase):** The preferred value is measured, typically derived from a transformer specification sheet or test report. This data should be the measured DC resistance of single winding at nominal tap and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**From, To, and Tertiary Windings Grounding Resistance (Ohms):** The preferred value is measured or calculated, typically derived from a ground grid design, transformer test report, or other test report. This data should be the measured DC resistance of single winding at nominal tap and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Blocking Device Status (From, To, and Tertiary Windings):** Indicate whether a GIC blocking device is installed and is operational on the From winding in this field. GIC blocking devices on transformer windings are rare.

**DC Resistance of From, To, and Tertiary Windings Blocking Device (Ohms):** Currently, most load flow software tools that support a GIC analysis module assume that if a blocking device is installed and active, that the DC resistance of that block is infinite. In other words, the winding is either blocked from participating in GIC flow or not. It is expected that in future versions GIC analysis modules that software will support an actual DC resistance for the blocking device to more precisely model GIC flow through the transformer winding. Input the known DC resistance of the blocking device in Ohms, if known.
**Transformer Model in DC Network:** Entered as 0 to represent the transformer according to its vector group, or entered as 1 to represent the transformer as a T-model. **Important note:** given that all transformers in the SPP MDWG model series are expected to have vector groups defined, the model Data Submitter should avoid entering 1 in this field. In future revisions of the MDWG model data collection, this field may be eliminated. However, due to an outstanding PSS®E software ambiguity for symmetric phase shifting transformers, this field is retained.

Symmetric phase shifting transformers modulate real power flow, typically to a narrow specified range. These are represented in the load flow model by two-winding transformer representations that utilize the “MW symmetrical PAR” or “MW asymmetrical PAR” control mode. These transformers should be modeled as the YNa vector group with Connection Codes (CC) 9 or 19, reflecting that the winding 1 impedance represents the zero sequence impedance of the regulating transformer, the winding 2 impedance represents the zero sequence impedance of the series transformer, and the shunt branch represents the tertiary winding impedance. If the symmetric phase shifting transformer is entered this way, the “Transformer Model in DC Network” (TMODEL) should be entered as 0. However, in those rare cases when a vector group is not specified for the symmetric phase shifting transformer, the PSS®E software needs to establish a default for the transformer T-model representation in DC analysis. This is accomplished by entering the “Transformer Model in DC Network” (TMODEL) as 1.

**Shunts**

The Shunts sheet is intended to collect information necessary for modeling direct paths to ground that contribute to the magnitude of GIC flow on the power system. There are two key observations that need to be considered when submitting shunts data for MDWG model data collection. First, Switch Shunt capacitor devices are not considered by GIC analysis software. This is due to the expectation that capacitive shunts are GIC blocks and inductive devices would be intentionally placed out-of-service so as to not exacerbate GIC during GMD events. Second, line reactor devices are very important for modeling GIC. However, the practice of representing line reactors is inconsistent amongst model builders, where some explicitly model line reactor shunts at buses in the transmission line path, while others incorporate the impedance of the line shunt into the data record of the transmission line branch itself. It is important to confirm how line shunts are being modeled. The model Data Submitter is expected to provide the following data:

**From, To Bus Number (Planning Model):** Self-explanatory; where the fixed shunt is located. In the case where the line shunt is modeled as part of the transmission line branch, enter the bus number of the branch terminal end that is closest to the physical location of the line reactor. If line reactors reside at both ends of the branch, make two separate line item entries (e.g., separate rows) to reflect two separate line reactors.

**Line or Bus (Planning Model):** Enter the method of modeling the shunt device, as either explicitly at a bus or as part of a line (branch).

**Located at which end (From, To, or Both):** For line shunts modeled as part of the transmission line branch, enter at which terminal ends the line reactor is installed. Otherwise, leave this field blank.
**Winding Connection Type:** This information is not currently used as part of the analysis, but may be relevant in future assessments. Enter the winding configuration as Wye, Grounded-Wye, or Delta. This information should be annotated on the shunt specification sheet or as part of a test report.

**Shunt DC Resistance (Ohms/Phase):** The preferred value is measured, typically derived from the shunt specification sheet or test report. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Shunt Grounding Resistance (Ohms):** The preferred value is measured or calculated, typically derived from a ground grid design, shunt test report, or other test report. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Branch**

The Branch sheet is intended to reflect the characteristics of the transmission lines that serve as the current-carrying conductors participating in the varying magnetic field, giving rise to GIC. It is noted that most of the information for transmission lines is already part of load flow models. The model Data Submitter is expected to provide the following data:

**Branch Resistance (pu):** Most branch resistances are known in per unit, so an automatic conversion to ohms per phase is included here. The ohms per phase quantity can be entered explicitly in the DC Resistance cell or, if Branch Resistance (pu) is left as zero, the GIC module will use the AC branch resistance already in load flow model. It is important to note: this “Branch Resistance” field refers to the DC branch resistance that will characterize the transmission line in the DC model representation for GIC analysis. For the purpose of the MDWG model data collection, all transmission line conductor DC resistances shall be entered at 50 °C.

For an identical temperature, transmission line branch per phase resistances vary slightly between DC resistance and AC resistance. However, for large diameter transmission line conductors, the difference between AC and DC resistances may exceed 10%, at a common temperature. This is especially important when considering whether a transmission line employs bundled conductors. For the purpose of MDWG model data collection, it is acceptable to use the AC branch resistance already in the load flow model, if the AC resistance is based on 50 °C or less. However, care must be taken when using AC resistances as approximations of the DC resistance, especially when the AC resistance is based on temperatures greater than 50 °C. While conductor resistivity increases approximately linearly with temperature between 20 °C to 75 °C, the difference between DC and AC resistances may vary non-linearly with temperature given other transmission line characteristics, leading to significant differences in resistance. In other words, knowing that transmission line AC resistances are often entered into the load flow models at 25 °C, using this AC resistance as a conservative approximation for DC resistance is acceptable. However, any AC resistance entered into

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28 The Transmission Line Characteristics (TMLC) software and Line Properties Calculator (LineProp) software are common tools used by model Data Submitters to calculate AC transmission line branch impedances. Both of these software packages do not allow any other conductor temperature assumption other than 25 °C, when calculating AC resistance calculation, unless default manufacturer data tables are overwritten. Typical transmission line conductor tables furnished by manufacturers provide AC resistances at 25 °C, 50 °C, and 75 °C.
the load flow model using temperatures greater than 50 °C must be corrected to 50 °C prior to using the quantity as the approximation for DC resistance.

Ultimately, to perform a conservative study of GMD effects, the smaller the transmission line DC resistance, the larger the GIC that will be developed. Therefore, DC resistances entered at 50 °C are preferred. AC resistances corrected to and entered at 50 °C or less are an acceptable alternative.

**Real part of total branch GMD-induced electric field (volts):** This field is intended to allow a particular branch to experience a higher or lower induced electric field than the uniform field applied to other branches. In other words, if there is a reason to expect a particular transmission line will experience more or less induced field during a benchmark GMD event (line length times the TPL-007-3 reference geoelectric field of 8V/km), enter the alternative real-part electric field in volts. **Caution:** do not enter zeros into this field unless the transmission line is not intended to participate in the development of an electric field due to GMD. Rare examples of when this may be the case include buried or undersea transmission cable. Leave this field blank to apply the uniform electric field automatically.

**Imaginary part of total branch GMD-induced electric field (volts):** This field is intended to allow a particular branch to experience a higher or lower induced electric field than the uniform field applied to other branches. In other words, if there is a reason to expect a particular transmission line will experience more or less induced field during a benchmark GMD event (line length times the TPL-007-3 reference geoelectric field of 8V/km), enter the alternative imaginary-part electric field in volts. **Caution:** do not enter zeros into this field unless the transmission line is not intended to participate in the development of an electric field due to GMD. Rare examples of when this may be the case include buried or undersea transmission cable. Leave this field blank to apply the uniform electric field automatically.

**Loads**  
**Note:** loads for GMD data submittal are expected to be exceptions and are uncommon! Albeit rare, the possibility exists that a relevant load may be connected at EHV/HV levels that offers a ground path for GIC. Likewise, it may be desirable for a Data Submitter to include data for a solidly-grounded load direct-served through an EHV/HV autotransformer (uncommon), such as with a large industrial load. All loads do not need to be entered into the Loads sheet! The Loads sheet is intended to collect information necessary for modeling the rare direct paths to ground introduced due to load connections that contribute to the magnitude of GIC flow on the power system. The model Data Submitter is expected to provide the following data:

**Winding Connection Type:** This information is not currently used as part of the analysis, but may be relevant in future assessments. Enter the winding configuration as Wye, Grounded-Wye, or Delta. For loads with a dedicated step-down transformer, this information may be annotated on the step-down transformer specification sheet or as part of a test report for the primary winding (non-autotransformer) or the primary-secondary autotransformer winding configuration.

**Load DC Resistance (Ohms/Phase):** The Data Submitter should take care when entering this value. Remember, for autotransformers, the common winding (primary and secondary) is likely grounded. When determining the load DC resistance, consider that the actual impedance of the load to ground is connected to the secondary in parallel with the tapped common winding. The preferred value is
measured DC resistance of single phase and adjusted to 75 °C, but the common winding to ground resistance may be a suitable proxy for DC analysis. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.

**Load Grounding Resistance (Ohms):** The preferred value is measured or calculated, typically derived from the step-down transformer test report indicating the transformer neutral grounding. This data should be the measured DC resistance of single phase and adjusted to 75 °C. **Caution:** do not convert this resistance to per unit Ohms per phase; retain the actual Ohmic quantity.
### SECTION 12: APPENDIX V MOD-032-1
#### ATTACHMENT 1

**MOD-032-1 – ATTACHMENT 1**

The table, below, indicates the information that is required to effectively model the interconnected transmission system for the Near-Term Transmission Planning Horizon and Long-Term Transmission Planning Horizon. Data must be shareable on an interconnection-wide basis to support use in the Interconnection-wide cases. A Planning Coordinator may specify additional information that includes specific information required for each item in the table below. Each functional entity responsible for reporting the respective data in the table is identified by brackets “[functional entity]” adjacent to and following each data item. The data reported shall be as identified by the bus number, name, and/or identifier that is assigned in conjunction with the PC, TO, or TP.

<table>
<thead>
<tr>
<th>steady-state period (Items marked with an asterisk indicate data that vary with system operating state or conditions. Those items may have different data provided for different modeling scenarios)</th>
<th>dynamics (If a user-written model(s) is submitted in place of a generic or library model, it must include the characteristics of the model, including block diagrams, values and names for all model parameters, and a list of all state variables)</th>
<th>short circuit period</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Each bus [TO]</td>
<td>1. Generator [GO, RP (for future planned resources only)]</td>
<td>1. Provide for all applicable elements in column “steady-state” [GO, RP, TO]</td>
</tr>
<tr>
<td>a. nominal voltage</td>
<td>2. Excitation System [GO, RP (for future planned resources only)]</td>
<td>a. Positive Sequence Data</td>
</tr>
<tr>
<td>b. area, zone and owner</td>
<td>3. Governor [GO, RP (for future planned resources only)]</td>
<td>b. Negative Sequence Data</td>
</tr>
<tr>
<td>a. real and reactive power*</td>
<td>5. Demand [LSE]</td>
<td>2. Mutual Line Impedance Data [TO]</td>
</tr>
<tr>
<td>b. in-service status*</td>
<td>6. Wind Turbine Data [GO]</td>
<td>3. Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</td>
</tr>
<tr>
<td>3. Generating Units [GO, RP (for future planned resources only)]</td>
<td>7. Photovoltaic systems [GO]</td>
<td></td>
</tr>
<tr>
<td>a. real power capabilities - gross maximum and minimum values</td>
<td>8. Static Var Systems and FACTS [GO, TO, LSE]</td>
<td></td>
</tr>
<tr>
<td>b. reactive power capabilities - maximum and minimum values at real power capabilities in 3a above</td>
<td>9. DC system models [TO]</td>
<td></td>
</tr>
<tr>
<td>c. station service auxiliary load for normal plant configuration (provide)</td>
<td>10. Other information requested by the Planning Coordinator or</td>
<td></td>
</tr>
</tbody>
</table>

---

29 For purposes of this attachment, the functional entity references are represented by abbreviations as follows: Balancing Authority (BA), Generator Owner (GO), Load Serving Entity (LSE), Planning Coordinator (PC), Resource Planner (RP), Transmission Owner (TO), Transmission Planner (TP), and Transmission Service Provider (TSP).

2 For purposes of this item, aggregate Demand is the Demand aggregated at each bus under item 1 that is identified by a Transmission Owner as a load serving bus. An LSE is responsible for providing this information, generally through coordination with the Transmission Owner.

3 Including synchronous condensers and pumped storage.
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. AC Transmission Line or Circuit [TO]</strong></td>
<td><strong>Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]</strong></td>
</tr>
<tr>
<td>d. regulated bus* and voltage set point* (as typically provided by the TOP)</td>
<td></td>
</tr>
<tr>
<td>e. machine MVA base</td>
<td></td>
</tr>
<tr>
<td>f. generator step up transformer data (provide same data as that required for transformer under item 6, below)</td>
<td></td>
</tr>
<tr>
<td>g. generator type (hydro, wind, fossil, solar, nuclear, etc)</td>
<td></td>
</tr>
<tr>
<td>h. in-service status*</td>
<td></td>
</tr>
<tr>
<td><strong>5. DC Transmission systems [TO]</strong></td>
<td></td>
</tr>
<tr>
<td><strong>6. Transformer (voltage and phase-shifting) [TO]</strong></td>
<td></td>
</tr>
<tr>
<td>a. nominal voltages of windings</td>
<td></td>
</tr>
<tr>
<td>b. impedance(s)</td>
<td></td>
</tr>
<tr>
<td>c. tap ratios (voltage or phase angle)*</td>
<td></td>
</tr>
<tr>
<td>d. minimum and maximum tap position limits</td>
<td></td>
</tr>
<tr>
<td>e. number of tap positions (for both the ULTC and NLTC)</td>
<td></td>
</tr>
<tr>
<td>f. regulated bus (for voltage regulating transformers)*</td>
<td></td>
</tr>
<tr>
<td>g. ratings (normal and emergency)*</td>
<td></td>
</tr>
<tr>
<td>h. in-service status*</td>
<td></td>
</tr>
</tbody>
</table>
7. Reactive compensation (shunt capacitors and reactors) [TO]
   a. **admittances (MVars) of each capacitor and reactor**
   b. **regulated voltage band limits* (if mode of operation not fixed)**
   c. **mode of operation (fixed, discrete, continuous, etc.)**
   d. **regulated bus* (if mode of operation not fixed)**
   e. **in-service status***

8. Static Var Systems [TO]
   a. **reactive limits**
   b. **voltage set point***
   c. **fixed/switched shunt, if applicable**
   d. **in-service status***

9. **Other information requested by the Planning Coordinator or Transmission Planner necessary for modeling purposes. [BA, GO, LSE, TO, TSP]**