2025 Wind/Solar/ESR Effective Load Carrying Capability Summer and Winter Study Scope

REVISION HISTORY

DATE OR VERSION NUMBER	AUTHOR	CHANGE DESCRIPTION	COMMENTS
8/9/2024	Fredrick Kolp	Initial Draft	
01/30/2025	SPP		SAWG Approved

CONTENTS

BACKGROUND AND OBJECTIVE

Effective Load Carrying Capability (ELCC) is defined as the amount of incremental load a resource can dependably and reliably serve while being measured against a reliability metric threshold. ELCC is typically measured as the amount by which a system's load can increase when a resource is added to the system while maintaining a system reliability metric. This ELCC study will consist of probabilistic analyses utilizing the loss of load expectation (LOLE) metric of 1 day in 10 years (or 0.1 days/year). The intent of the ELCC Study is to determine and apply the accredited capacity, on a pro rata basis, to wind, solar, and ESR resources in the SPP footprint that are projected to be in service for Summer 2026 and Winter 2026/2027.

There are two components in determination of the system ELCC capacity: system base case and system change case. Both components for the applicable Summer and Winter seasons will utilize 0.1 days/year metric across the totality of the historical years simulated. The system base case will include load and all resources except for wind resources, solar resources, and Energy Storage Resources (ESR), excluding pumped storage hydroelectric resources. The system change case will include all resources and load. In essence, the system ELCC capacity in megawatt (MW) is determined as:

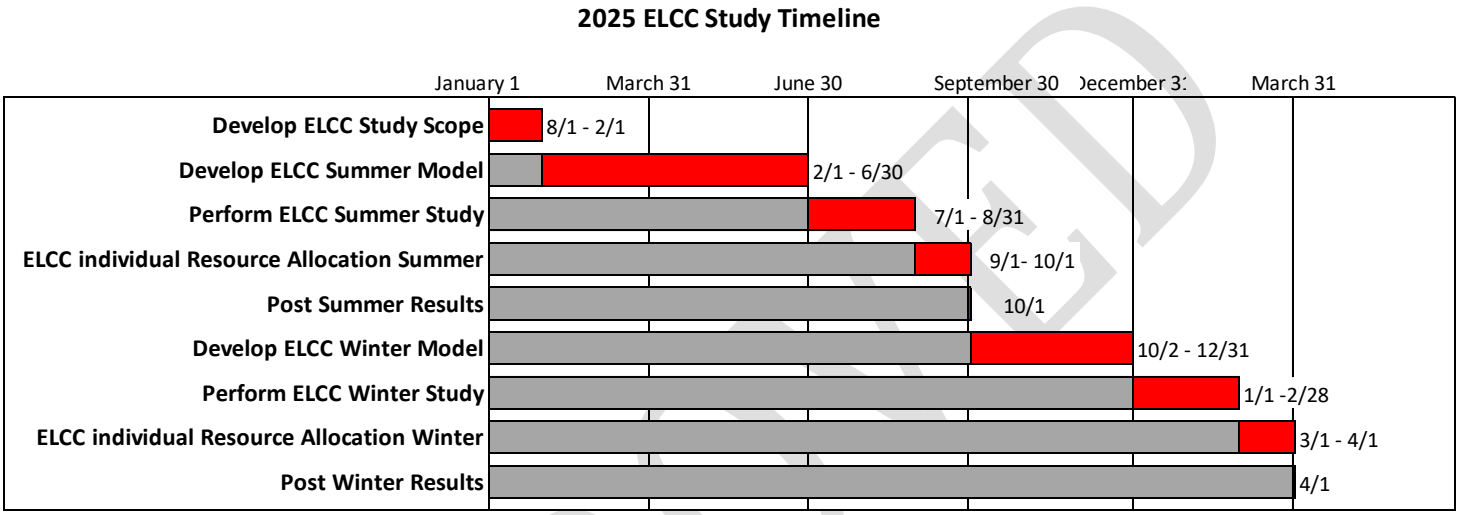
$$\frac{System\ ELCC\ Base\ Case\ (MW)}{-\ System\ ELCC\ Change\ Case\ (MW)}$$
$$Total\ System\ ELCC\ (MW)$$

The ELCC process will consist of three phases (i.e., tier determination, accreditation, and allocation), which will be applied to both winter and summer seasons. In the first phase, the value of nameplate capacity will be determined for each tier of wind and solar resources. The second phase will assess the accredited value for each wind and solar tier on an SPP footprint-wide basis using the ELCC method. To effectively measure ELCC of a resource, the capacity associated with the resource under study will need to be isolated from the rest of the system by calculating the LOLE of the system with and without the resource. The difference in the amount of increased load between the study system with and without the resource under study will be the accredited value of the system. For the final phase, the accredited capacity will be allocated to each wind and solar facility based on historical performance as detailed in the Capacity

Allocation section of this scope. For Energy Storage Resources (ESRs), three distinct duration levels will be analyzed. The ESRs will be assigned the ELCC accredited value from the applicable tier of the facility. The results will be posted by October 1, 2025 and April 1, 2026 and will be applicable for the 2026 Summer Season and 2026-2027 Winter Season respectively.

STUDY TIMELINE

The ELCC process is performed every year, and the results will be applied as accredited capacity to meet the requirements outlined in Attachment AA of the SPP Tariff. The timeline for the analysis is as follows:



INPUT DATA AND ASSUMPTIONS

SOFTWARE

The ELCC Study will utilize the Strategic Energy Risk Valuation Model (SERVM) software from Astrapé Consulting, which is also used for SPP's Loss of Load Expectation (LOLE) Study. SERVM is a multi-area reliability and economic simulation tool that allows users to evaluate resource adequacy not only based on physical reliability metrics, such as the one day in ten years threshold, but also to assess the economics of such resource adequacy standards. SERVM combines the economic dispatch characteristics of production cost models with the granularity and probabilistic simulation capabilities of multi-area reliability models.

MODELING AND ASSUMPTIONS

The assumptions and model used in the 2025 Loss of Load Expectation (LOLE) Study will serve as the basis for the ELCC analysis. However, the study will consider resources and load projected for the 2026 summer and winter seasons provided in the 2025 Summer and Winter workbook submissions.

ADDITIONAL STUDY ASSUMPTIONS

In addition to the assumptions explained above, SPP Staff will also include the following study assumptions:

- Wind base and change cases will consider the effects of existing solar and ESR facilities as well as those projected to come into service during the specified season with hybrids unlinked
- Solar base and change cases will consider the effects of existing wind and ESR facilities as well as those projected to come into service during the specified season with hybrids unlinked
- ESR base and change cases will consider the effects of existing wind and solar facilities as well as those projected to come into service during the specified season with hybrids unlinked

- Demand Response programs, planned and maintenance outages, and transmission limitations between the LOLE zones from the 2025 LOLE Study will not be considered in any base or change cases of the ELCC study
- The utilization of hydroelectric resources above the statutory load obligation will be modeled in a manner to not impact the accreditation of ELCC resources
- ESRs will be modeled utilizing the following unit specific variables:
    - Stand- alone batteries
    - Max Capability – the maximum capacity the ESR can output to the system for one (1) hour. Each ESR in the analysis will be 100 MW in size
    - Storage Capability – the overall maximum capacity of the ESR. This is calculated by multiplying the Cap max by the maximum duration
    - Charge Max Capability – the maximum capacity the ESR can charge in one (1) hour. Each ESR in the analysis will have the capability to charge up to 100 MW in an hour
    - Cycle Efficiency – the cycle efficiency of the ESR, assumed to be 85%[1]
    - Dispatch Method – Economic Arbitrage
- Resources and load will be updated based on 2025 workbook submissions and representative of forecasted year 2026
    - Forecasted resources expected to be in service by summer 2026 shall be submitted by June 1, 2025 to be included in the summer ELLC Study
    - Forecasted resources expected to be in service by winter 2026-2027 shall be submitted by December 1, 2025 to be included in the winter ELLC Study

SYSTEM ELCC CONSIDERATION

A system ELCC analysis will be conducted to determine the total ELCC value of all ELCC resources combined, including hybrid resources. In system ELCC analysis, hybrids resources will be considered linked. This will be performed on expected existing or submitted resources for the ELCC analysis and be factored in when determining the ELCC value of each resource through the allocation process. The system ELCC analysis is performed to ensure the summation

[1] Cole, Wesley, and Akash Karmakar. "Cost Projections for Utility-Scale Battery Storage: 2023 Update." Golden, CO: National Renewable Energy Laboratory, 2023. https://www.nrel.gov/docs/fy23osti/85332.pdf.

of all individual wind, solar, and ESR ELCC resource studies are equivalent to the total ELCC MW for the system. In addition, considerations of generation interconnection limits will be included in the system ELCC analysis. For individual ELCC allocations, the percentage of each category will be allocated based on each resources' performance.

STUDY SCENARIOS

Scenarios for the ELCC studies are listed in Table 1.

Table 1: Scenario Breakdown

Scenario	Season	ELCC Type	Tier or Nameplate Capacity
1	Summer	Wind	1
2	Summer	Wind	1 and 2
3	Winter	Wind	1
4	Winter	Wind	1 and 2
5	Summer	Solar	1
6	Summer	Solar	1 and 2
7	Winter	Solar	1
8	Winter	Solar	1 and 2
9	Summer	All ELCC Resource Types (System ELCC)	Wind – Tier 1, 2 Solar – Tier 1, 2 ESR – Existing
10	Winter	All ELCC Resource Types (System ELCC)	Wind – Tier 1, 2 Solar – Tier 1, 2 ESR – Existing
11	Summer	4-hour ESR	1,000 MW
12	Winter	4-hour ESR	1,000 MW
13	Summer	6-hour ESR	1,000 MW
14	Winter	6-hour ESR	1,000 MW
15	Summer	8-hour ESR	1,000 MW
16	Winter	8-hour ESR	1,000 MW

STUDY PROCESS

WIND AND SOLAR TIER DETERMINATION

The first step of the study process is to identify the amount of nameplate generation that needs to be analyzed. The installed nameplate generation registered in the Integrated Marketplace and future facilities provided in the 2025 Workbook submissions will be divided into two tiers and applied to both solar and wind, which is listed in detail below. Facilities that are studied will be divided into two tiers based on the methodology used below.

WIND TIERS

The total nameplate generation of Tier 1 shall consist of the sum of each LRE's wind nameplate generation; this is determined by taking the sum of the LRE's firm transmission service amount for each of its wind resources used to meet its resource adequacy requirement. Firm transmission service amounts will be determined based on Open Access Same-Time Information System (OASIS) information as of June 1st and December 1st for the respective 2026 Summer and 2026/2027 Winter Seasons. Tier 1 will have priority in the study queue and will have its ELCC capacity value determined first. Tier 2 shall consist of the sum of the wind resources that do not meet the requirements for Tier 1. If the resources analyzed in Tier 1 do not have firm transmission service on the full contract or ownership amount, the remaining nameplate rating capability of the resource will be studied in Tier 2. Wind facilities registered in the SPP Integrated Marketplace without firm transmission service and not identified through the 2025 Workbook submission process will be assigned to Tier 2.

SOLAR TIERS

The total nameplate generation of Tier 1 shall consist of the sum of each LRE's Tier 1 solar nameplate generation; this is determined by taking the sum of the LRE's firm transmission service amount for each of its solar resources used to meet its resource adequacy requirement. Firm transmission service amounts will be determined based on OASIS information as of June 1st and December 1st for the respective 2026 Summer and 2026/2027 Winter Seasons. Tier 1 will have priority in the study queue and will have its ELCC capacity value determined first. Tier

2 shall consist of the sum of the solar resources not included in Tier 1. If the resources analyzed in Tier 1 resources do not have firm transmission service on the full contract or ownership amount, the remaining nameplate rating capability of the resource will be studied in Tier 2. Solar facilities registered in the SPP Integrated Marketplace without firm transmission service and not identified through the 2025 Workbook submission process will be assigned to Tier 2. After the facilities have been assigned to the appropriate tiers, an ELCC analysis will be performed on each tier.

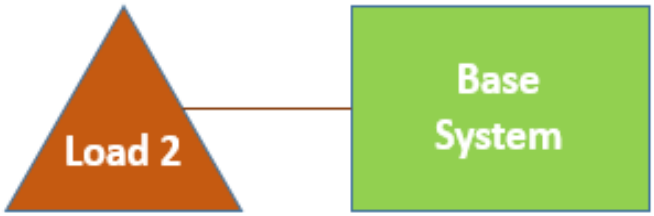
ELCC ANALYSIS

The second step of the study process is to derive the ELCC values of each scenario. In order to determine the ELCC values, the reliability metric breakout approved for the Summer and Winter PRM of each scenario will be the benchmark used for the respective season to determine the amount of incremental load the SPP system can withstand without exceeding the reliability metric. Even though the capacity values will be different for each scenario, the methodology of the analysis will remain the same. The steps below show the high-level process and equations utilized for the analysis for each study scenario.

1. Determine the incremental load the SPP system can withstand without exceeding the reliability threshold of one day in ten years. The same amount of perfect negative generation will be added in each hour of the simulation to incrementally add load to the system.

2. Determine the incremental load the SPP system can withstand without exceeding the reliability threshold by excluding the generation type of interest and keeping all other

generation constant. The same amount of perfect negative generation will be added in each hour of the simulation to incrementally add load to the system.



3. Calculate the accredited ELCC value by taking the difference between load required in step one and load required in step two, divided by the amount of analyzed nameplate capacity.

$$\textbf{ELCC Value} = \frac{(\textbf{Load 1} - \textbf{Load 2})}{\textbf{Nameplate Capacity}}$$

4. Steps 2 and 3 will be repeated for all study scenarios and compared to the incremental load added in step 1. These steps will be applied to each season separately.

After the total capacity values have been determined for all wind, solar, and ESR scenarios, the data will be plotted using the installed or proposed nameplate generation versus the ELCC calculated percentage. The incremental amount for each tier will be determined by the ELCC difference of the listed scenarios in each ELCC resource type. For example, ELCC of Tier 2 Wind resources for the Summer Season will be the difference of ELCC values between Scenario 1 and Scenario 2.

STUDY METHOD

Wind and Solar

In order to measure the ELCC of a particular resource, effects on reliability need to be isolated for that resource. The basic concept of an ELCC analysis focuses on two situations: one including the resource(s) of interest and the other excluding them from the system. For the wind and solar studies, the benchmark SPP system, also referred to as the base case, is defined as system load supplied by all other resource types in the SPP footprint that are not being evaluated in the

instant analysis. For example, the wind ELCC Study base case included load, conventional resources, solar resources, and other resources, excluding wind. The base case and subsequent change cases focused on the resource type being analyzed while all other resources remain constant between the cases.

The wind ELCC Study base case will include load, conventional resources, solar resources, hydroelectric resources, ESRs, and all other resources excluding wind. The solar ELCC Study base case will include load, conventional resources, wind resources, hydroelectric resources, ESRs, and all other resources excluding solar. The first change case for the wind resources and solar resources will include Tier 1 wind resources or Tier 1 solar resources, as applicable. The second change case will include all wind or all solar resources. The base case and all change cases for the wind resources and solar resources will be analyzed by adding or removing the same amount of load in every hour of the assessment period until 0.1 days per year LOLE is achieved across all historical weather years analyzed for each season. The 0.1 days per year LOLE metric will be used for all base and change cases for each season. The amount of load added or removed in each change case will be compared to the amount of load added in the base case to derive an ELCC megawatt (MW) for each change case across all historical weather years analyzed. The difference in total ELCC MW of the base case and the first change case is the ELCC MW assigned to Tier 1. The difference in total ELCC MW of the first change case and the second change case is the ELCC MW assigned to Tier 2.

For the wind ELCC study, Change Case A considered Tier 1 wind resources; and Change Case B considered all wind resources. The wind ELCC study cases are shown below in Table 2. The values for the solar ELCC study are shown below in Table 3.

Table 2. System Wind ELCC Cases

Study Case	Wind Resource Designation
Wind Base Case	No wind resources
Wind Change Case A	Tier 1 wind resources
Wind Change Case B	All wind resources (Tier 1 and Tier 2)

Table 3. System Solar ELCC Cases

Study Case	Solar Resource Designation
Solar Base Case	No solar resources
Solar Change Case A	Tier 1 solar resources
Solar Change Case B	All solar resources (Tier 1 and Tier 2)

ENERGY STORAGE RESOURCES

The Energy Storage Resource (ESR) ELCC Study base case will include load, conventional resources, all wind and solar resources, and all other resources and programs excluding ESRs. The base case and subsequent change cases focused on the resource type being analyzed while all other resources remain constant between the cases.

APPLICATION OF SYSTEM ELCC SCENARIOS

After the total ELCC values have been determined for each ELCC resource type, the summation of all ELCC values will be compared to the system ELCC analysis scenarios. If the summation of all ELCC resource types exceed the system ELCC value, then the ELCC values attributed to each ELCC resource type will be scaled appropriately to account for the system ELCC limit. For example, if the wind ELCC value for all tiers is 5,000 MW, the solar ELCC value for all tiers is 1,000 MW, and the ESR ELCC value for all tiers is 500 MW, then the summation of all individual ELCC resource types is 6,500 MW. If the system ELCC value for the same ELCC resources results in 6,000 MW, then each ELCC resource type will be adjusted to 92.3% of the ELCC results for its resource type. In this example, 4,615 MW would be allocated to wind facilities (5,000 MW x 92.3%), 923 MW would be allocated to solar facilities (1,000 MW x 92.3%), and 462 MW would be allocated to ESRs (500 MW x 92.3%). This will only be applied to the currently installed or projected resources submitted to be analyzed in the ELCC studies for the 2026 Summer and 2026- 2027 Winter seasons.

ALLOCATION PROCESS

WIND AND SOLAR RESOURCES

Once each tier has had its accredited capacity value determined, the accredited capacity will be allocated, i.e., a percentage of the total accredited capacity, to each individual wind or solar resource for its corresponding tier. The allocation to Tier 1 wind and solar resources, for each applicable season, will be based on the average production output of individual resource during the top 3% net peak load hours of LRE load shapes, which will accredit these resources based on historical performance for serving their contracted load. Full or partial forced events identified as Out of Management Control ("OMC"), as defined by NERC, that impact the production output of an individual resource included in Tier 1 shall be excluded from the determination of allocation of wind resources and solar resources in Tier 1. Individual resources of Tier 1 will then receive a pro-rata share of the total accredited capacity compared to the total historical average capacity value of all other wind resources or solar resources in the tier. The assignment to Tier 2 wind and solar resources will be based on the average historical production output from the top three percent (3%) Net Peak Load hours of SPP BA load shape, which will give these resources an accreditation percentage based on historical performance at the time of SPP peak hours.

The allocation process is divided into two categories based on commercial operation date, which are listed below:

A. <u>For Wind Facilities in service at least three years, historical performance will be determined using the following factors:</u>
    1. The available accredited capacity from the ELCC study will be allocated by selecting the hourly net power output values occurring during the top 3% of load hours for the LRE (Tier 1 resources) or SPP BA load (Tier 2 resources) for the peak season that is being analyzed. The yearly values selected will be averaged together to determine the amount of historical production during the top 3% load hours. At a minimum, the most recent three (3) years will be considered when selecting the top 3% load hours, not to exceed the most recent seven (7) years of commercial operation. Curtailment data will be obtained from the SPP Operations Department and added back into the resource wind

profile. If OMC information is provided for a facility, it will be added back into the facilities historical output.

a. The OMC information to be added back into historical output of the facility shall be provided by the resource owner or the entity contracted with the facility. If no shapes are provided to be added back into the historical shape, no other corrections will be made.

2. Only actual metered hourly net power output (MWH) data at the point of interconnection may be used, with the consideration of curtailment data.

3. If a wind or solar facility which has been in commercial operation greater than 3 years undergoes a technology change, it will continue to use the previous years' electrical output, unless the LRE or Generator Owner chooses to treat the existing facility as a new facility. If treated as a new facility it would be considered as a wind or solar facility which has been in commercial operation 3 years or less. The LRE or GO must notify SPP before the ELCC Study commences, no later than June 1st for Summer and December 1st for Winter.

B. <u>For wind or solar facilities in commercial operation three (3) years or less:</u>

1. A new wind or solar facility which does not have three (3) years of operational data may provide on-site hourly weather data (such as wind speed and solar irradiance data), and facility attributes (such as turbine power curves, inverter load ratios, etc.) to create a power production estimate by the facility owner or operator. SPP Staff will use those data if they are provided no later than June 1st, 2025 and December 1st, 2025 for the Summer and Winter seasons respectively. Estimated output values may be calculated from wind or solar data, if measured electrical output (MW) values are not yet available.
2. If a new wind or solar facility which does not have three (3) years of operational data does not provide estimated output values or data to create a production estimate, data correlated with the nearest wind or solar resource with a comparable capacity factor or technology vintage will be used to complete the appropriate data set. If no nearby resource has a comparable capacity factor, the output data from the nearest existing resource will be scaled up to mimic the power curve for the technology of the new resource.

a. If a new wind or solar resource does not provide historical estimated output that facility will be included in the annual ELCC study as a new facility in accordance with section 7.1.6.3.

ENERGY STORAGE RESOURCES

The total penetration of ESRs will dictate the percentage of accreditation assigned based on each ESR Tier, regardless of location of the resource. For example, if the penetration of ESRs is 4,000MW for a four-hour product and the accredited capacity is 3,800 MW from the ELCC analysis for these resources, then all four-hour ESRs would receive approximately 95% accreditation. Tier 1 ESR accreditation will be determined first, followed by Tier 2 for each duration type. Below lists the process for duration type when determining the ESR percentage of each duration. Within each duration type, energy storage resources with Firm Transmission Service (Tier 1 ESRs) will be allocated ELCC values before ESRs without Firm Transmission Service (Tier 2 ESRs). The ESR ELCC curves from the 2025 study will be used for the allocation. For all battery durations, if the penetration is less than 1000MW, the ELCC at 1000 MW will be used.

ESR with Eight Hour, or Greater Rating

Eight hour duration Electric Storage Resources identified as Tier 1 will be assigned the ELCC percentage of the eight hour duration curve for the total penetration amount of Electric Storage Resources identified as eight hour duration and Tier 1 for the applicable season.

ESR with Six Hour Rating

Six hour duration Electric Storage Resources identified as Tier 1 will be assigned the ELCC percentage of the six hour duration curve for the total penetration amount of Electric Storage Resources for the applicable season identified as:

i. Tier 1 Eight hour duration; and

ii. Tier 1 Six hour duration.

ESR with Four Hour Duration

Four hour duration Electric Storage Resources identified as Tier 1 will be assigned the ELCC percentage of the four hour duration curve for the total penetration amount of Electric Storage Resources for the applicable season identified as:

i. Tier 1 Eight hour duration;

ii. Tier 1 Six hour duration; and

iii. Tier 1 Four hour duration

ESR with Eight Hour, or Greater Rating – Tier 2

Eight hour duration Electric Storage Resources identified as Tier 2 will be assigned the ELCC percentage of the eight hour duration curve for the total penetration amount of Electric Storage Resources for the applicable season identified as:

i. All duration types of tier 1; and

ii. Tier 2 Eight hour duration.

ESR with Six Hour Rating – Tier 2

Six hour duration Electric Storage Resources identified as Tier 2 will be assigned the ELCC percentage of the six hour duration curve for the total penetration amount of Electric Storage Resources for the applicable season identified as;

i. All duration types of tier 1;

ii. Tier 2 Eight hour duration; and

iii. Tier 2 Six hour duration

ESR with Four Hour Rating – Tier 2

Four hour duration Electric Storage Resources identified as Tier 2 will be assigned the ELCC percentage of the six hour duration curve for the total penetration amount of Electric Storage Resources for the applicable season identified as:

i. All duration types of tier 1;

ii. Tier 2 Eight hour duration;

iii. Tier 2 Six hour duration; and

iv. Tier 2 Four hour duration.

ESR with Two Hour Rating

Based on the four-hour continuous availability requirement, two-hour ESRs would be accredited using the four-hour curve based on the penetration level; they would receive a maximum 50% accreditation and would be equalized to a four-hour duration ESR. The accreditation of the ESR would then be determined using the ELCC four-hour curve for the ESR penetration level of all ESRs on the system at the time of the ELCC assessment. The accreditation of Two Hour Rating Tier 1 and Two Hour Rating Tier 2 would be assessed after Four Hour Rating Tier 1 or Four Hour Rating Tier 2, respectively

REPORTING AND DELIVERABLES

The ELCC Study scope will be reviewed and approved by the SAWG. The results of the 2025 ELCC studies will be presented to the SAWG and used in the 2026 Resource Adequacy Workbook submittals (2026 Summer Season and 2026-2027 Winter Season). Wind, solar, and ESR results for currently installed or planned resources will be sent individually to LREs or Generation Owners by October 1, 2025 and April 1, 2026 for the Summer and Winter Results respectively. All resources will be submitted to the entity contracting for the facility as well the original owner of the facility. Additionally, staff will conduct a sensitivity on preserve reliability dispatch methods for ESR. However, this sensitivity will be conducted after tariff requirements are met. A report will also be created and posted to the SPP website upon completion of all analyses.