2020 ELCC Wind and Solar Study Report

SPP Resource Adequacy

July 2021

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1. EXECUTIVE SUMMARY

As retirements of conventional resources and the penetration of renewable resources in the SPP Balancing Authority Area (BAA) footprint increases over time, it becomes critical to correctly assess the capacity value of renewable resources. Over-valuing renewable resources' contribution can result in lower levels of system reliability and increased risks of potential unserved load; while under-valuing can result in additional cost. Consistent with policy approved by the Supply Adequacy Working Group (SAWG), Market and Operations Policy Committee (MOPC), and the Regional State Committee (RSC), SPP performed an Effective Load Carrying Capability (ELCC) study to assess the capacity value of existing renewable capacity and determine the impacts of continued renewable capacity growth in the SPP BAA footprint. ELCC is defined as the amount of incremental load a resource can reliably serve, while also considering probabilistic parameters of unserved load caused by forced outages, load uncertainty, and other factors.

Consistent with the policy approved by SAWG, MOPC, and RSC, this 2020 ELCC study was performed for informational purposes only. The ELCC policy whitepaper is currently going through the Revision Request Process (RR418) with expected approval in 2021. Implementation of the ELCC policy to be used as the official accreditation method for wind and solar resources in the SPP BAA footprint is scheduled to begin 2023 summer peak season. The method will replace the current accreditation methodology outlined in the SPP Planning Criteria. Likewise, the results of this method will be used by SPP entities as they plan for future resources to meet resource adequacy and transmission planning requirements.

<u>Wind Resources</u>

The 2020 ELCC study results indicate that with increasing penetrations of wind and solar resources, the capacity value provided by those resources, on a percent or per MW of nameplate capacity generally tends to decrease. The results indicate the total capacity available from wind to be 4,503 MW in the summer season and 4,590 MW in the winter season for an installed and projected nameplate capacity of 26,885 MW. Upon increasing the total installed capacity to 40,000 MW of wind, the accredited capacity totaled 5,718 MW in the summer season and 5,751

MW in the winter season. On a percentage basis, the summer ELCC value of the resources decreases from 16.8% with 26,885 MW of wind to 14.3% of 40,000 MW. The winter ELCC value of the resources decreases from 17.1% with 26,885 MW of wind to 14.4% of 40,000 MW, which is illustrated in Figure 1

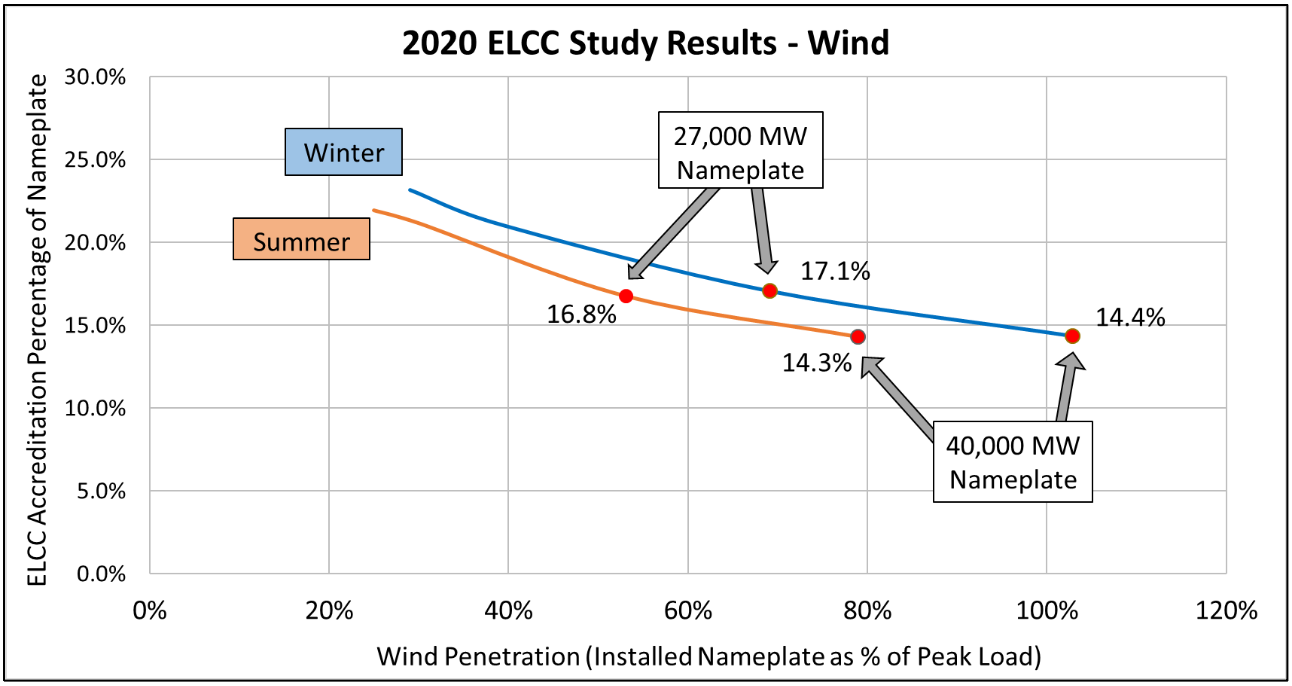

Figure 1: 2020 ELCC Study Results - Wind

<u>Solar Resources</u>

Historical output (years 2017-2019) from the installed existing solar facilities (275 MW) was used to determine the accredited capacity. The results from the 2020 Solar ELCC study indicates the total capacity available from solar to be 234 MW in the summer season and 89 MW in the winter season for an installed capacity of 275 MW. The summer ELCC percentage of these resources decreases from 85.1% with 275 MW of solar to 40.3% with 20,000 MW. The winter ELCC percentage of these resources decreases from 32.3% with 275 MW of solar to 6.0% with 20,000MW. These additional amounts of solar nameplate installations (1,000 MW and greater) utilized solar shapes from existing sites and additional potential sites based on the assumptions in Section 2 of this report. Figure 2 represents the 2020 ELCC solar results for each season.

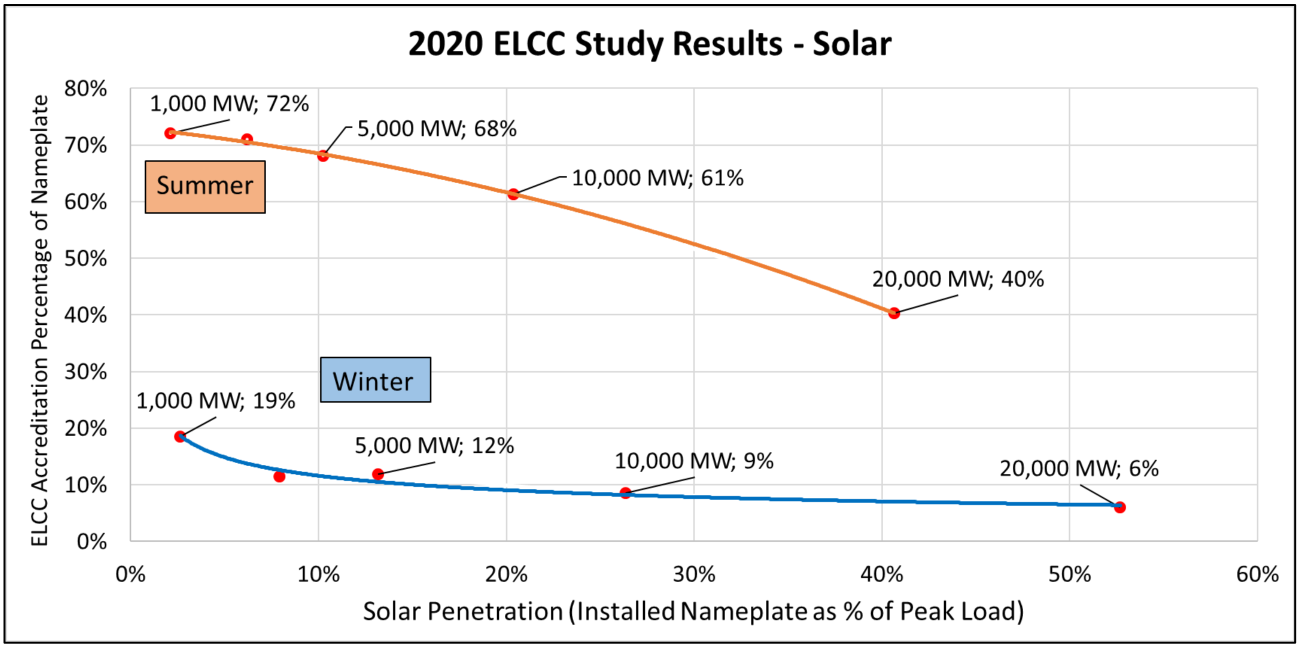

Figure 2: 2020 ELCC Study Results - Solar

In summary, the SPP ELCC analysis:

- Determined the amount of accredited capacity from 26,885 MW of installed nameplate wind was 4,503 MW in the summer and 4,590 MW in the winter when using 2012 to 2019 historical weather patterns. [1]
- Determined the amount of accredited capacity from 275 MW of installed nameplate solar was 234 MW in the summer and 89 MW in the winter when using historical output from years 2017 to 2019 of existing solar resources.
- Provided seasonal ELCC values for projected values of wind and solar facilities in the SPP footprint.

STATUS OF ELCC POLICY

Consistent with ELCC policy, this study was provided to stakeholders as an information only study. ELCC policy for the SPP Balancing Authority Area footprint was approved through a policy whitepaper by the Supply Adequacy Working Group (SAWG), Market and Operations Policy Committee (MOPC), and the Regional State Committee (RSC), in the 3rd quarter of the

[1] This assumes that all installed nameplate wind is qualified by an LRE to be used to meet load and/or planning reserves. Only a portion of this amount is currently qualified.

2019 cycle of stakeholder meetings. The ELCC policy is currently proposed to have an effective date starting for the 2023 summer peak season.

ACKNOWLEDGEMENTS

The scoping effort for this analysis began in April of 2020 at the SAWG. The stakeholder review process was an integral part of this study process and the participation and oversight of the SAWG was much appreciated by SPP staff. SPP staff also appreciates Astrapé Consulting for their assistance in the utilization of their expertise using the SERVM software.

2. SPP SYSTEM ELCC STUDY

BACKGROUND

Effective Load Carrying Capability (ELCC) is defined as the amount of incremental load a resource can reliably serve, while also considering probabilistic parameters of unserved load caused by forced outages, load uncertainty, and other factors. The magnitude of incremental load served which is derived in the ELCC analysis becomes the basis of the resource's accreditation. ELCC has been used for determining capacity value of resources since the 1960's when Garver demonstrated the use of Loss of Load Probability (LOLP) in the calculation of ELCC[2]. There are other utilities, Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs), including Midcontinent Independent System Operator (MISO) and California ISO (CAISO), that utilize the ELCC practices to determine capacity value of variable resources.

Using ELCC practices, a facility's accreditation (measured in MW) is a fractional probabilistic measure of the facility's nameplate rating that can be relied on to serve load. ELCC can express the value that generation contributes to a system as penetration of the specific resource type increases. Underestimating the contribution of variable generation resources to help meet system peaks can result in the need for additional generation capacity and higher system costs. Overestimating the ability of such variable generation resources to help serve system peaks can result in lower levels of system reliability and increased risks of potential unserved load.

The results of an ELCC study are dependent upon the selection of a specific reliability target. SPP utilizes the reliability metric of 1 day in 10 years (or 0.1 day/year), which is also used in the SPP Loss of Load Expectation (LOLE) analysis to determine the adequate planning reserve margin for the SPP BAA. LOLE is typically defined as the expected number of days or hours per period, usually a year, that an entity does not have enough capacity to meet load. If the loads are specified on an hourly basis, as is often the case, then the hourly LOLE is calculated by determining whether the entity has enough capacity available to serve the load for each hour of the year. In order to determine the seasonal ELCC accreditation, LOLE that occurred in the

[2] Garver, "Effective Load Carrying Capability of Generating Units," Aug. 1966

summer was exclusively used to determine the summer accredited capacity and LOLE that occurred in the winter was used to determine the winter accredited capacity.

SOFTWARE

The SPP Wind and Solar ELCC Study utilized the Strategic Energy Risk Valuation Model (SERVM) software package from Astrapé Consulting. 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.

MODEL INPUTS AND ASSUMPTIONS FOR THE WIND AND SOLAR STUDY

Many of the model inputs and assumptions (such as unit parameters, external transfers, DC Tie considerations, etc.) for the ELCC study were the same used in the 2019 Loss of Load Expectation (LOLE) Study[3]. The key differences in these assumptions were the exclusion of transmission limitations between modeled areas, exclusion of use of load forecast uncertainty, and inclusion of scenarios featuring increased levels of future projected nameplate wind and solar.

The transmission limitations between modeled areas within the SPP footprint were excluded from the ELCC analysis. Transmission system limitations resulting from congestion and generation deliverability are analyzed in other SPP operational and planning processes. Curtailed amounts of wind and solar generation, as provided and tracked in the SPP Marketplace, were added back into the hourly generation profiles used in the ELCC study and allocation process.

Perfect negative generation was utilized in the ELCC analysis to represent the "scaling of load" by applying a percentage of increase to each hour to reach the target reliability threshold. This generation was modeled in SERVM as a perfect generator with no outages to provide a constant negative capacity. When conducting preliminary ELCC simulations for the winter season, historical load shapes were initially increased on a percentage basis to a significant amount to

[3] 2019 SPP LOLE Study Report

reach the target reliability threshold. This method of scaling caused the historical load shapes to become distorted. The method of perfect negative generation accomplishes the same objective as the theory of scaling load while allowing the original load shape to remain untouched.

The ELCC analysis is performed with multiple weather years using historical data in order to account for any unusual high or low "outliers" in the data. ELCC is performed on data from one historical year at a time, thus only one accredited capacity value is derived per season for each modeled weather year.

WIND STUDY DETAILS

Various levels of nameplate capacity were modeled and analyzed to reflect the trend of accredited capacity as a variable of installed penetration. The initial analysis represented 26,885 MW of installed wind broken down by three tiers. The total nameplate generation of Tier 1 consists of the sum of each Load Responsible Entity's (LRE) wind nameplate generation that is determined by the taking the lesser of 1) the sum of the LRE's firm transmission service amount for each of its wind resources used to meet its resource adequacy requirement or 2) 35% of the LRE's average seasonal peak load for the previous three years. Tier 1 has priority in the study and has its ELCC capacity value determined first. Tier 2 consists of the sum of the wind resources with firm transmission service used to meet the LREs' resource adequacy requirements that are in excess of 35% of the LRE's average seasonal peak load for the previous three years. If the resources analyzed in Tier 1 and 2 do not have firm transmission service on the full contract or ownership amount, the remaining nameplate rating capability of the resource is studied in Tier 3. Tier 3 consists of all studied wind not included in Tier 1 and Tier 2. Wind facilities registered in the SPP Integrated Marketplace not identified through the 2020 Workbook submission process were assigned to Tier 3. This method and analysis reflects the approved ELCC policy for wind and solar resources.[4]

An additional value of 40,000 MW of wind was also analyzed. This additional value was achieved by scaling the existing wind locations to reach an SPP wind nameplate of 40,000 MW. The scaling approach was chosen as to not predict where future wind installations would be located, which could inaccurately bias the results for any future installed capacity. For example, if the selection

[4] ELCC Solar and Wind Policy

of future wind was predominantly located in higher wind capacity areas, it could alter the results compared to the wind resource locations actually in commercial operation. Therefore this approach scales wind installations at the locations they are currently located. The 40,000 MW capacity value was studied and calculated purely for trending purposes.

The ELCC Wind analysis was performed on each weather year from 2012 to 2019. The results from each season of each weather year were then trended into an average to produce consistency from year to year in accrediting capacity.

SOLAR STUDY DETAILS

For the solar potion of the ELCC study, 275 MW of solar resources were assumed to be in service. Because over half of these solar resources (185MW) came into operation in January 2017 or later, the 275 MW ELCC solar study only utilized weather years 2017 to 2019. The projected solar ELCC analysis (1,000MW, 3,000MW, 5,000MW, 10,000MW, 20,000MW) utilized only historical years 2012 to 2017 in accordance with the weather years modeled as explained in the following Irradiance section. The results for each analysis from each season of each weather year were then trended into an average.

For the projected solar ELCC analysis, the solar modeled in the 2019 Integrated Transmission Plan (ITP) Future 2[5] was considered to increase the amount of solar penetration rather than scaling the existing 275 MW of installed capacity. The 2019 ITP assumes fifty-three (53) additional sites in twelve (12) states totaling approximately 4,000MW of additional solar resources shown in Table 1. These sites are also consistent with the sites used in the 2019 Solar ELCC study.[6]

Table 1: Solar by State Used in the ELCC Solar Study

State	Installed Solar (MW)
Arkansas	93
Iowa	1
Kansas	1,061
Louisiana	9
Minnesota	2
Missouri	66

[5] 2019 ITP Study Scope
[6] 2019 SPP Solar ELCC Study Report

Nebraska	585
New Mexico	316
North Dakota	7
Oklahoma	1,077
South Dakota	293
Texas	772
Total	**4,282**

Irradiance

Unlike wind, the ELCC Solar Study required historical data that SPP did not possess for the future scenarios of projected solar capacity. Only the existing solar sites (275 MW) in the SPP footprint contained the historical data needed for the study. Therefore, a correlation was made to directly correlate irradiance data with MW output of the existing solar facilities and applied the correlation to the 53 new sites based on location. As expected, the southwest corner of the SPP footprint (New Mexico, Texas, and Oklahoma) resulted in higher irradiance than the northeastern corner (North Dakota and South Dakota). The irradiance data was obtained from the National Renewable Energy Laboratory (NREL) using the National Solar Radiation Database (NSRDB)7. NREL is a federal laboratory dedicated to research, development, commercialization, and deployment or renewable energy and energy efficiency technology. The NSRDB is a complete collection of meteorological and solar irradiance data sets for the United States.

Irradiance is defined as the output of light energy from the sun, which is the radiant flux (power), received by a surface per unit area usually measured in the watt per square meter (W/m^2). Solar irradiance consists of three main measurements: Direct Normal Irradiance (DNI), Diffuse Horizontal Irradiance (DHI), and Global Horizontal Irradiance (GHI). DNI is the amount of solar radiation from the direction of the sun. DHI is the component of radiation relating directly to an unclear atmosphere or reflections from clouds. GHI is known as total solar radiation, which includes DNI, DHI, and the solar zenith angle (i.e. the angle of the sun compared to the angle directly overhead).

Historical GHI values from 2012 to 2017 for the fifty-three (53) additional solar sites were obtained from site specific NREL data using the NSRDB, and the 53 sites were assigned historical MW output values based on the correlation derived from the existing solar facilities in SPP. GHI was the irradiance measurement used for the solar study since it accounts for other

[7] NREL NSRDB Link

measurements from the sun. An NREL GHI map by location shown in Figure 3 to represent irradiance penetration values for twenty (20) years, 1996 to 2016, for example purposes.

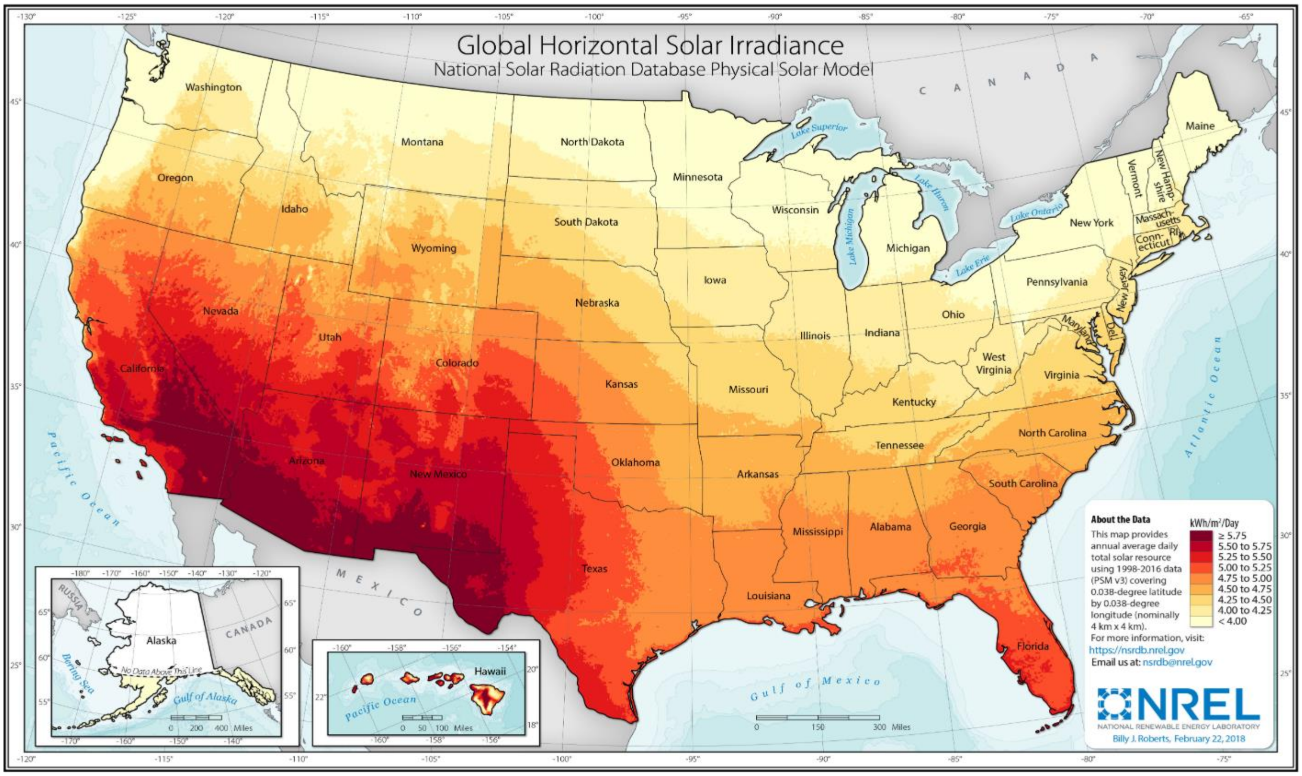

Figure 3: NREL Map of GHI from 1996 to 2016.

All other inputs and assumptions used from the LOLE study remained unaltered in the ELCC wind and solar analysis to isolate the accredited capacity value and its effects from multiple weather patterns. A detailed list of other assumptions and inputs can be found in the 2019 LOLE Study Report[8].

STUDY METHOD[9]

In order to measure the ELCC of a particular resource, reliability effects need to be isolated for the resource(s). The LOLE value (days/year) of each wind or solar scenario will be the benchmark used to determine the amount of incremental load the SPP system can serve without exceeding the reliability threshold of one day in ten years. The basic concept of an ELCC analysis

[8] 2019 Loss of Load Expectation Report

[9] As part of the Solar and Wind ELCC Policy whitepaper, the study methodology for ELCC studies for wind and solar resources is being added to the SPP Business Practice Manual

focuses on two situations: one including the resource(s) of interest and the other excluding them from the system. The situation with the resource(s) should be more reliable and result in less loss of load instances, which in turn requires a higher amount of incremental load to reach 0.1 days/year in lost load. Figure 4 and Figure 5 represent the two situations and how an ELCC value is determined. The incremental amount of load represented by "Load 1" and "Load 2" is the load amount needed to reach a loss of load value of 0.1 days/year.

The following steps are taken:

1. Determine the incremental load amount the SPP system can withstand without exceeding the reliability threshold of one day in ten years for the SPP wind or solar generation.

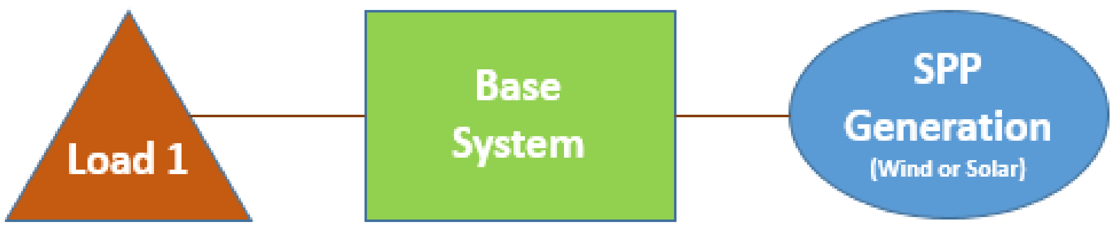

Figure 4: Diagram of System with Wind or Solar Resources

2. Determine the incremental load amount the SPP system can withstand without exceeding the reliability threshold of one day in ten years for the SPP wind or solar generation at zero MW.

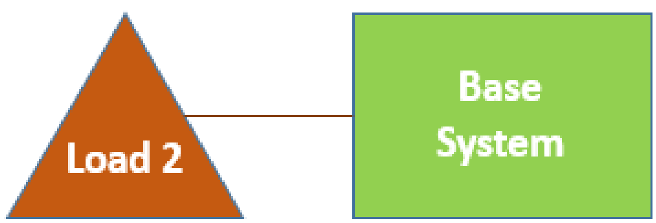

Figure 5: Diagram of System without Wind or Solar Resources

3. Calculate ELCC for the of nameplate wind or solar. This will be done by taking the difference of load required in step one compared to the amount required in step two divided by the amount of nameplate.

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

SIMULATION

Twenty (20) random seed[10] representations were applied to each scenario to create additional variation in unit availability and dispatch between simulations. This is defined as one case. Forty (40) iterations were applied to each case to reach statistical convergence and reduce the standard error between results. In total, 800 iterations (40 iterations * 20 seed values) were applied to each wind and solar scenario.

RESULTS

Wind Resources

Sixty-four (64) total wind scenarios were analyzed: four different levels of installed nameplate capacity applied to two seasons for eight weather years. Figure 6 shows the results for each weather year at different levels of installed nameplate wind capacity for the summer season, and Figure 7 shows the results for each weather year for the winter season. As the penetration of installed nameplate capacity increases, the capacity value as a fraction of the installed nameplate capacity decreases. This is due to the impact of wind's effect compared to on-peak hours when demand is at its highest, i.e. the highest expectation for lost load. During the ELCC study, dispatchable (conventional and hydro) generation is used to serve the "net load" of every hour. "Net load" refers to the amount of demand minus the output of renewable energy resources for every hour. The amount of wind generation for on-peak conditions shifts the hour of interest when considering "net load" instead of "gross load". ("Gross load" is defined as the amount of hourly demand without the consideration of energy from renewable resources.) Therefore, the larger contribution that on-peak wind generation has on shifting the peak hours of interest, the higher capacity value the resources will have. Table 2: **ELCC Wind Summer**

[10] A random seed representation assigns a pre-commitment outage and maintenance schedule before the simulations begin. As the amount of randomly generated seed values increases, the variability in iterations increases as well.

Results by Weather Year shows the ELCC accredited percentage and MW value of each wind scenario for the summer season, and Table 3 shows the same values for the winter season.

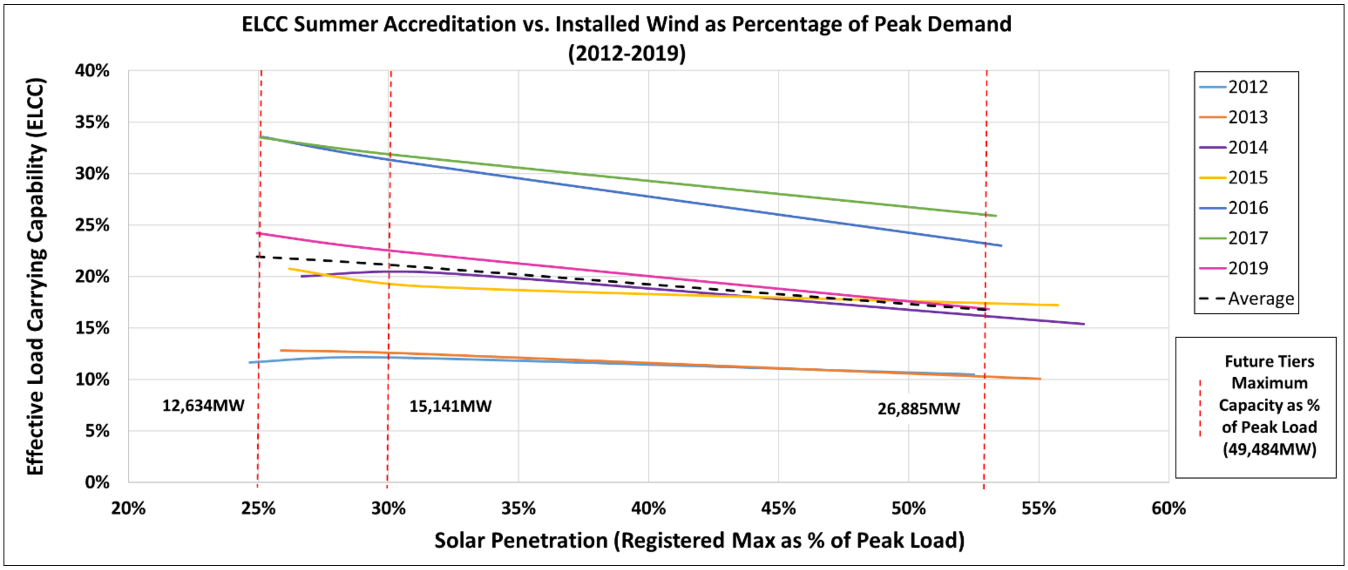

Figure 6: ELCC Wind Summer Results by Weather Year

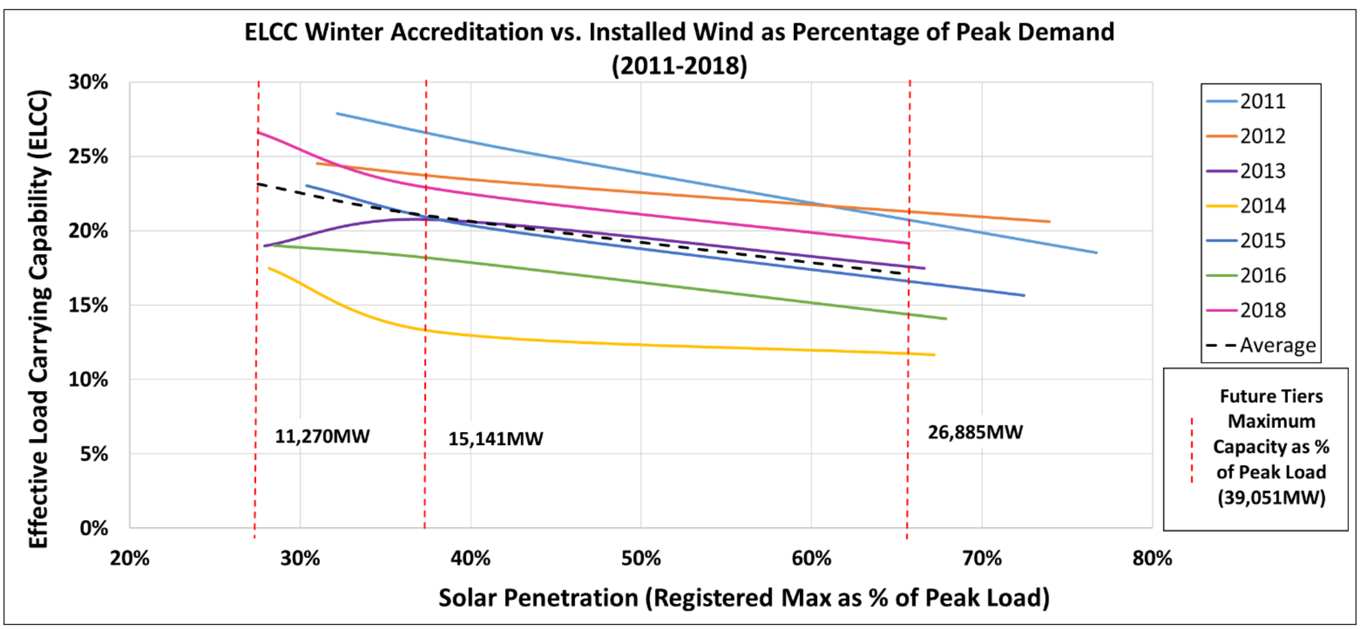

Figure 7: ELCC Wind Winter Results by Weather Year

Table 2: ELCC Wind Summer Results by Weather Year

ELCC Summer Values for Installed Wind Amounts per Study Year					
Weather Year		Installed Nameplate Wind Capacity			
		12,634 MW	15,141 MW	26,885 MW	40,000 MW
	2012	11.6%, 1,470 MW	12.1%, 1,838 MW	10.5%, 2,810 MW	9.9%, 3,976 MW
	2013	12.8%, 1,618 MW	12.5%, 1,892 MW	10.0%, 2,701 MW	9.9%, 3,959 MW
	2014	20.0%, 2,527 MW	20.3%, 3,079 MW	15.4%, 4,129 MW	13.9%, 5,567 MW
	2015	20.8%, 2,623 MW	19.0%, 2,883 MW	17.2%, 4,626 MW	13.9%, 5,541 MW
	2016	33.6%, 4,241 MW	31.3%, 4,739 MW	23.0%, 6,177 MW	18.3%, 7,331 MW
	2017	33.5%, 4,232 MW	31.9%, 4,824 MW	25.9%, 6,966 MW	20.7%, 8,262 MW
	2018	19.0%, 2,398 MW	19.6%, 2,968 MW	15.2%, 4,094 MW	13.2%, 5,262 MW
	2019	24.2%, 3,060 MW	22.6%, 3,417 MW	16.8%, 4,523 MW	14.6%, 5,849 MW
	Cumulative Average	***21.9%, 2,771 MW***	***21.2%, 3,205 MW***	***16.8%, 4,503 MW***	***14.3%, 5,718 MW***

Table 3: ELCC Wind Winter Results by Weather Year

ELCC Winter Values for Installed Wind Amounts per Study Year					
		Installed Nameplate Wind Capacity			
		11,270 MW	15,141 MW	26,885 MW	40,000 MW
Weather Year	2012	27.9%, 3,141 MW	25.3%, 3,825 MW	18.5%, 4,979 MW	15.1%, 6,043 MW
	2013	24.5%, 2,765 MW	23.3%, 3,527 MW	20.6%, 5,538 MW	16.7%, 6,697 MW
	2014	19.0%, 2,140 MW	20.8%, 3,142 MW	17.5%, 4,702 MW	15.9%, 6,341 MW
	2015	17.5%, 1,971 MW	13.2%, 2,003 MW	11.7%, 3,134 MW	9.9%, 3,958 MW
	2016	23.0%, 2,596 MW	20.2%, 3,060 MW	15.6%, 4,206 MW	13.0%, 5,206 MW
	2017	19.0%, 2,140 MW	18.1%, 2,737 MW	14.1%, 3,792 MW	12.3%, 4,934 MW
	2018	27.7%, 3,126 MW	25.0%, 3,783 MW	19.4%, 5,222 MW	15.8%, 6,333 MW
	2019	26.6%, 2,998 MW	23.0%, 3,481 MW	19.2%, 5,151 MW	16.2%, 6,499 MW
	Cumulative Average	***23.2%, 2,610 MW***	***21.1%, 3,195 MW***	***17.1%, 4,590 MW***	***14.4%, 5,751 MW***

It is recognized that certain wind resources will have higher capacity factors and will perform better during peak load periods than others because of geographical location, technology type or years of commercial operation. Therefore, a process that allocates the total available ELCC across the SPP footprint based on location and performance is warranted. The methodology for allocating the ELCC accredited amount is addressed in the ELCC Allocation Methodology Whitepaper[11].

[11] As part of the approved Solar and Wind ELCC Policy whitepaper, the allocation methodology is being added to SPP Planning Criteria

Solar Resources

Sixty-six (66) solar scenarios were analyzed: one level of installed solar capacity applied to each season for three weather years and five different projected levels of installed solar applied to each season for six weather years. Figure 8 shows the results for each weather year for future solar capacity for the summer season, and Figure 9 shows the results for each weather year for future solar capacity for the winter season. Table 4 shows the ELCC accredited percentage and MW value of each solar scenario for the summer season, and Table 5 shows the ELCC accredited percentage and MW value of each scenario for the winter season.

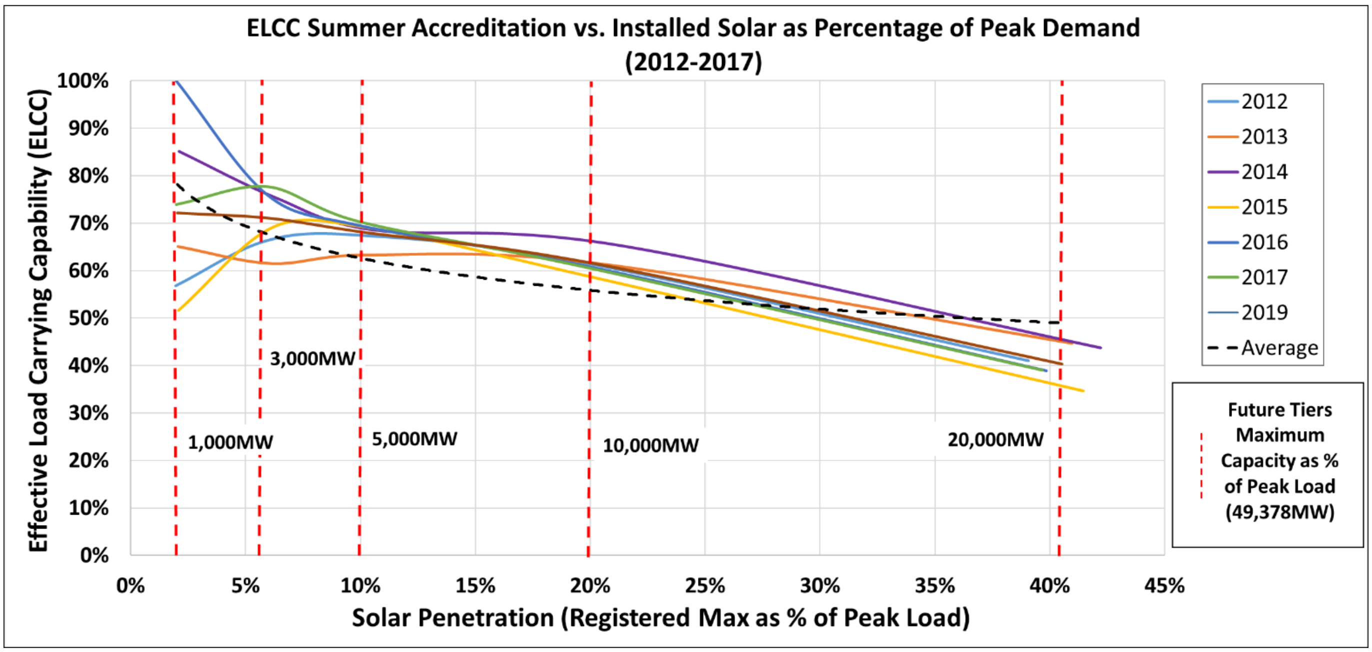

Figure 8: ELCC Solar Summer Results by Weather Year

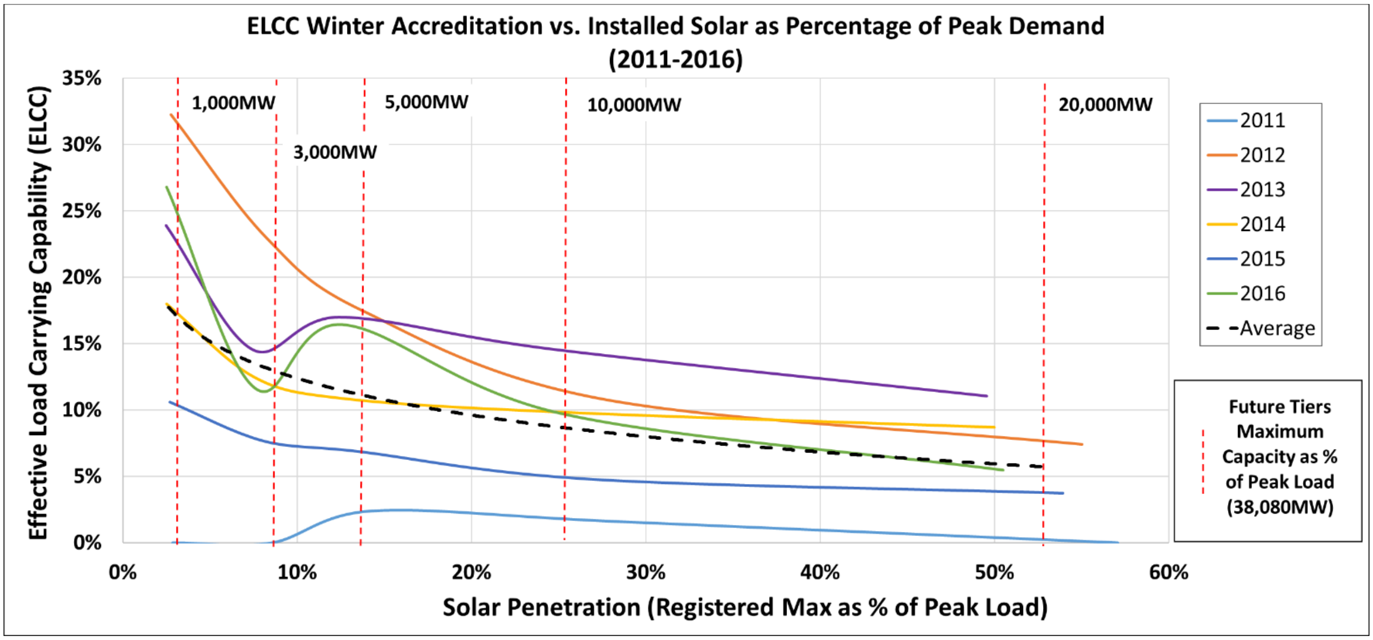

Figure 9: ELCC Solar Winter Results by Weather Year

Table 4: ELCC Solar Summer Results by Weather Year

ELCC Summer Values for Installed Solar Amounts per Study Year							
Weather Year		Installed Nameplate Solar Capacity					
		275 MW	1,000 MW	3,000 MW	5,000 MW	10,000 MW	20,000 MW
	2012	N/A	56.8%, 568 MW	66.3%, 1,988 MW	67.5%, 3,377 MW	61.9%, 6,185 MW	41.0%, 8,196 MW
	2013	N/A	65.1%, 651 MW	61.5%, 1,846 MW	63.4%, 3,168 MW	61.5%, 6,147 MW	44.7%, 8,942 MW
	2014	N/A	85.2%, 852 MW	75.4%, 2,261 MW	68.6%, 3,430 MW	65.5%, 6,546 MW	43.7%, 8,741 MW
	2015	N/A	51.6%, 516 MW	69.2%, 2,076 MW	69.0%, 3,449 MW	57.9%, 5,792 MW	34.7%, 6,940 MW
	2016	N/A	100%, 1,000 MW	75.9%, 2,276 MW	69.5%, 3,476 MW	60.9%, 6,089 MW	38.9%, 7,783 MW
	2017	68.3%, 188 MW	73.9%, 739 MW	77.7%, 2,331 MW	70.4%, 3,518 MW	60.7%, 6,068 MW	39.0%, 7,809 MW
	2018	100%, 275 MW	N/A	N/A	N/A	N/A	N/A
	2019	86.9%, 239 MW	N/A	N/A	N/A	N/A	N/A
	Cumulative Average	***85.1%, 234 MW***	***72.1%, 721 MW***	***71.0%, 2,130 MW***	***68.1%, 3,403 MW***	***61.4%, 6,138 MW***	***40.3%, 8,069 MW***

Table 5: ELCC Solar Winter Results by Weather Year

ELCC Winter Values for Installed Solar Amounts per Study Year							
Weather Year		Installed Nameplate Solar Capacity					
		275 MW	1,000 MW	3,000 MW	5,000 MW	10,000 MW	20,000 MW
	2011	N/A	0%, 0 MW	0%, 0 MW	2.4%, 119 MW	1.6%, 158 MW	0%, 0 MW
	2012	N/A	32.2%, 322 MW	22.9%, 688 MW	17.5%, 874 MW	10.8%, 1,083 MW	7.4%, 1,484 MW
	2013	N/A	23.9%, 239 MW	14.5%, 436 MW	17.0%, 849 MW	14.6%, 1,455 MW	11.0%, 2,208 MW
	2014	N/A	18.0%, 180 MW	12.5%, 375 MW	10.9%, 544 MW	9.8%, 984 MW	8.7%, 1,736 MW
	2015	N/A	10.6%, 106 MW	7.6%, 229 MW	6.9%, 343 MW	4.8%, 475 MW	3.7%, 742 MW
	2016	36.5%, 100 MW	26.8%, 268 MW	11.7%, 350 MW	16.4%, 821 MW	9.7%, 969 MW	5.5%, 1,090 MW
	2017	9.5%, 26 MW	N/A	N/A	N/A	N/A	N/A
	2018	51.1%, 141 MW	N/A	N/A	N/A	N/A	N/A
	Cumulative Average	***32.3%, 89 MW***	***18.6%, 186 MW***	***11.5%, 346 MW***	***11.8%, 592 MW***	***8.5%, 854 MW***	***6.0%, 1,210 MW***

It is important to note the lower levels of penetration could result in higher ELCC solar accreditation if new facilities coming into commercial operation over the next five year are more prevalent in the southwestern part of the SPP BAA. Likewise, if new facilities coming into commercial operation over the next five years are more prevalent in the northeastern part of the SPP BAA, the ELCC solar accreditation could be less than the results represented above.

3. CONCLUSION

The concept(s) of ELCC is to accurately estimate the value of wind and solar resources relied upon to meet system capacity needs for planning reserve purposes. The methodology is based upon an understanding that an underestimation of the contribution of variable generation resources, such as wind or solar, to help meet forecast system peaks can result in the need for additional generation capacity and higher system costs. Likewise, overestimating the ability of such variable generation resources to help serve system peaks can result in lower levels of system reliability and increased risks of unserved load. Consistent with approved policy, SPP performed an ELCC analysis for the installed wind amount of 26,885 MW and has determined the ELCC available for wind is 4,503 MW in the summer season and 4,590 MW in the winter season. The analysis also determined that the ELCC available for 275 MW of installed solar is 234 MW in the summer season and 89 MW in the winter season.

APPENDIX A: LIST OF ACRONYMS

BAA	Balancing Authority Area
CAISO	California ISO
DHI	Diffuse Horizontal Irradiance
DNI	Direct Normal Irradiance
ELCC	Effective Load Carrying Capability
GHI	Global Horizontal Irradiance
ISO	Independent System Operator
LFU	Load Forecast Uncertainty
LOLE	Loss of Load Expectation
LOLP	Loss of Load Probability
LRE	Load Responsible Entity
NREL	National Renewable Energy Laboratory
NSRDB	National Solar Radiation Database
MISO	Midcontinent Independent System Operator
MOPC	Market and Operations Policy Committee
MW	Megawatt
Tariff	Open Access Transmission Tariff
RAW	Resource Adequacy Workbook
RSC	Regional State Committee
RTO	Regional Transmission Organization
SAWG	Supply Adequacy Working Group
SERVM	Strategic Energy & Risk Valuation Model
SPP	Southwest Power Pool