2022 ELCC ESR Study Report

SPP Resource Adequacy

February 2023

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1. EXECUTIVE SUMMARY

As retirements of conventional resources and the penetration of renewable resources in the SPP Balancing Authority (BA) Area increases over time, it becomes critical to correctly assess the capacity value of renewable and energy storage resources. Over-valuing a resource's contribution can result in lower levels of system reliability and increased risks of potential unserved load, while under-valuing can result in additional cost. Meeting the requirement of SPP policy and governing documents, Staff performed an Effective Load Carrying Capability (ELCC) study to assess the capacity value of Energy Storage Resources (ESRs) in relation to the SPP BA Area. ELCC is defined as the amount of incremental load a resource can reliably serve, while also considering probabilistic parameters of unserved load.

Implementation of the ELCC policy is to be used as the accreditation method for battery facilities in the SPP BA Area, effective June 1, 2023. This method replaces the previous accreditation methodology outlined in the SPP Planning Criteria. Likewise, the results of this method will be used by SPP entities beginning with the 2023 Resource Adequacy Workbook submissions outlined in Attachment AA of the SPP Tariff.

Meeting the requirement of the study scope approved by the Supply Adequacy Working Group (SAWG), staff performed an ELCC study to assess four-hour (4-hour), six-hour (6-hour), and eight-hour (8-hour) ESRs for both summer and winter seasons. Specifically, the ESR study analyzed battery resources. Stored energy in batteries can be dispatched during high load hours. As battery capacity and duration increase, a system can afford to generate less energy. As a result, the ELCC accreditation of batteries goes down. And as the battery duration increases, the rate of decline in ELCC decreases. The study results are shown below.

Summer season ESR accreditations:

- 4-hour ESR: 100% (1,000MW), 96% (3,000MW), and 84% (5,000 MW)
- 6-hour ESR: 100% (1,000MW), 98% (3,000MW), and 95% (5,000 MW)
- 8-hour ESR: 100% (1,000 MW), 97% (3,000MW), and 96% (5,000MW)

Winter season ESR accreditations:

- 4-hour ESR: 83% (1,000MW), 71% (3,000MW), and 51% (5,000 MW)
- 6-hour ESR: 83% (1,000MW), 79% (3,000MW), and 58% (5,000 MW)
- 8-hour ESR: 89% (1,000 MW), 82% (3,000MW), and 61% (5,000MW)

1.1 ACKNOWLEDGEMENTS

The stakeholder review process was an integral part in this study, and SPP staff appreciates the participation and oversight of the Supply Adequacy Working Group (SAWG).

2. SPP SYSTEM ELCC ESR STUDY

2.1 OVERVIEW

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. 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 the capacity value of resources since the 1960's when Garver demonstrated the use of Loss of Load Probability (LOLP) in the calculation of ELCC[1]. There are other utilities, Independent System Operators (ISOs), and Regional Transmission Organizations (RTOs) that utilize 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 BA Area. In order to determine the seasonal ELCC accreditation, LOLE that occurred in the 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.

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

2.2 SOFTWARE

The ESR ELCC study utilized the Strategic Energy Risk Valuation Model (SERVM) software package from Astrapé Consulting. SERVM is a production-cost software, which performs a Security Constrained Economic Dispatch while utilizing a Monte-Carlo algorithm when varying the uncertainty of load and availability of capacity through multiple simulations.

2.3 MODEL INPUTS AND ASSUMPTIONS

Model inputs for the ESR ELCC study are similar to that of wind and solar portion of the ELCC study[2]. Two main differences in the ESR study are that hydro power generation was constant at 3,173 MW and inclusion of batteries. The following parameters were modeled for batteries:

- Stand-alone batteries
- 100 MW Maximum Capacity output limit per hour
- Cycling efficiency of 90%[3]
- 4-, 6-, and 8-hour durations
- Battery Penetration Levels: 1,000 MW, 3,000 MW, and 5,000 MW
- Economic arbitrage dispatch
- Demand Response Programs excluded
- 2012 to 2021 weather years analyzed together
- Forced, planned, and maintenance outages were not assigned to batteries

2.4 STUDY SCENARIOS

Scenarios for the ELCC study analyzed aforementioned batteries with 4-, 6-, and 8-hour durations with varying capacities.

Table 1 below shows the total number of scenarios (18) that were applied to each study year to create an average ELCC curve per ESR duration type.

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[2] 2022 ELCC Wind and Solar Study Report

[3] The value 90% for cycle efficiency was derived by taking the average of Li-ion ESR listed in the following resources: https://www.eesi.org/papers/view/energy-storage-2019 & eia.gov/analysis/studies/electricity/batterystorage/pdf/battery_storage.pdf

Table 1: ELCC ESR Scenarios

Scenario	Season	ESR Duration	Total ESR Nameplate (MW)
1	Summer	4-hour	1,000
2	Summer	4-hour	3,000
3	Summer	4-hour	5,000
4	Winter	4-hour	1,000
5	Winter	4-hour	3,000
6	Winter	4-hour	5,000
7	Summer	6-hour	1,000
8	Summer	6-hour	3,000
9	Summer	6-hour	5,000

Scenario	Season	ESR Duration	Total ESR Nameplate (MW)
10	Winter	6-hour	1,000
11	Winter	6-hour	3,000
12	Winter	6-hour	5,000
13	Summer	8-hour	1,000
14	Summer	8-hour	3,000
15	Summer	8-hour	5,000
16	Winter	8-hour	1,000
17	Winter	8-hour	3,000
18	Winter	8-hour	5,000

2.5 STUDY METHOD

In order to determine the ELCC of a particular resource, reliability effects 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 ESR study, 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 ESR ELCC Study base case included load, conventional resources, all wind and solar resources, and all other resources except for ESR. The base case and subsequent change cases focused on the resource type being analyzed while all other resources remain constant between the cases.

Table 2 shows an example calculation of the 4-hour ESR ELCC study; this example uses Change Cases with its average values. 6-hour and 8-hour ESRs are calculated using the same method.

Table 2: System ESR with 4-hour duration ELCC Calculation Example

ESR Nameplate Capacity	No ESRs	1,000 MW	3,000 MW	5,000 MW
System Load Addition (MW)	7,061	8,061	9,929	11,238
Difference between base case and change case		1,000	2,868	4,177
ELCC Percentage (%)		100%	96%	84%

The base case and all subsequent change cases were analyzed by adding the same amount of load (also referred to as perfect negative generation) in every hour of the assessment period until an LOLE threshold of 0.1 days/year is achieved. The amount of incremental load added in each change case was compared to the amount of incremental load added in the base case to derive an ELCC MW for each change case, shown in Figure 1 and Figure 2.

Figure 1: Diagram of System without ESR

Figure 2: Diagram of System with ESR

2.6 SIMULATION

Thirty (30) random seed[4] representations were applied to each scenario to create additional variation in unit availability and dispatch between simulations; this is defined as one case. Fifty (50) iterations were applied to each case to reach statistical convergence and reduce the standard error between results. In total, 15,000 iterations (50 iterations x 30 seed values x 10 weather years) were applied to each ESR scenario.

2.7 RESULTS

Summer Season

The ELCC accreditation results for 4-hour, 6-hour, and 8-hour ESRs with varying capacities in summer season scenarios (see

Table 1) are shown in Table 3: Summer ELCC Accreditation of 4-hour, 6-hour, and 8-hour ESRTable 3 and Figure 3. These results were calculated based on aggregated years from 2012 to 2021 with specific settings in SERVM that allowed ESRs to be dispatched based on economic arbitrage, discharged during high load hours and charged during low load hours. Figure 3, expressed as a percentage of nameplate capacity with respect to varying ESR capacities, illustrate the overall trend of ELCC accreditation decreases as the penetration of battery installations increase. It also illustrates that for the longer of the ESRs' duration, the rate of decline in ELCC decreases. . The results in Figure 3 demonstrate that as ESR installations increase, the system has to charge the batteries and therefore generates less energy to serve load. Consequently, the ELCC accreditation of ESRs decrease. Also, ESRs with longer durations slow the rate of decrease in ELCC accreditation because it can help serve load for a longer period. The accreditation for 4-hour ESR decreased from 100% to 84% for installations ranging from 1,000MW to 5,000MW. For 6-hour ESR, the accreditation decreased from 100% to 95% and 8-hour ESR accreditation decreased from 100% to 96% for the same range of installations. Full table of summer season results are shown in Table 3 below.

[4] 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.

Table 3: Summer ELCC Accreditation of 4-hour, 6-hour, and 8-hour ESR

Duration \ Capacity	1,000 MW	3,000 MW	5,000 MW
4-hour	100%	96%	84%
6-hour	100%	98%	95%
8-hour	100%	97%	96%

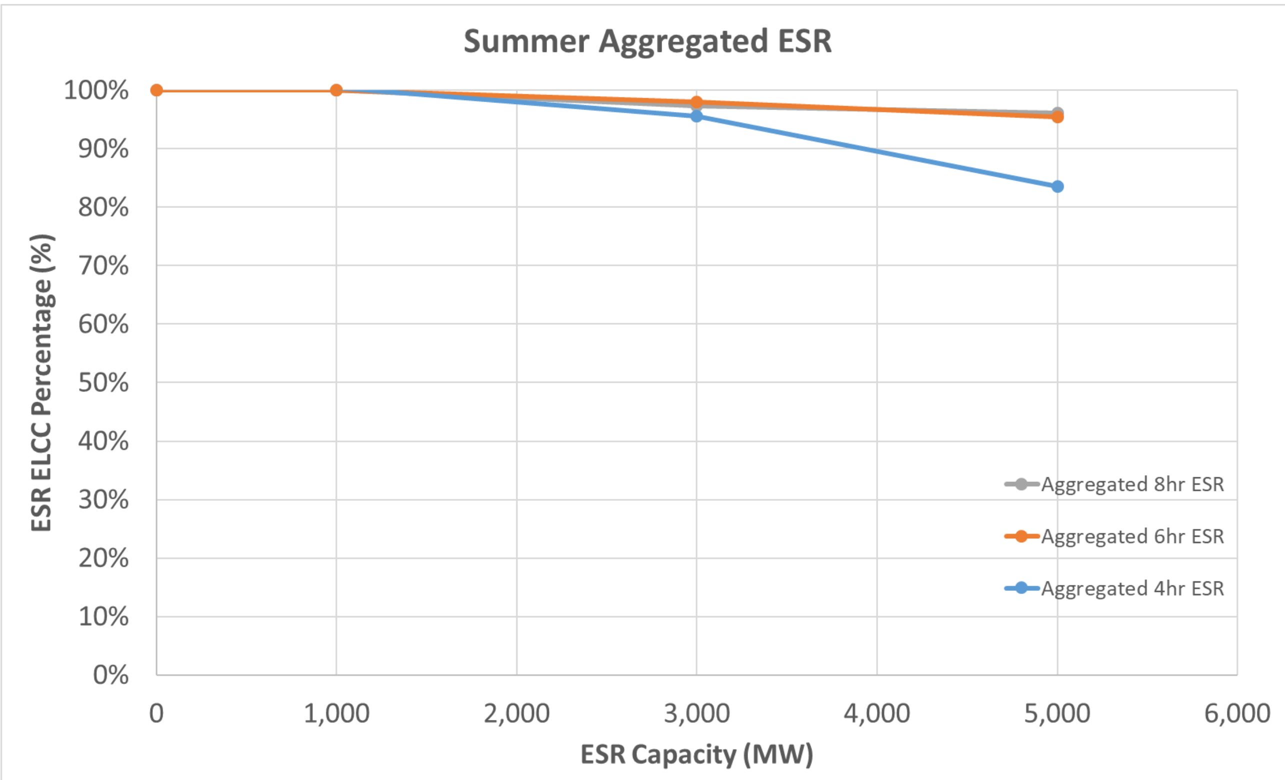

Figure 3: 2022 Aggregated Summer ESR ELCC Accreditation

<u>Winter Season</u>

Table 4 and Figure 4 illustrate the ELCC accreditation for 4-hour, 6-hour, and 8-hour ESR with varying capacities for the winter season scenarios (see

Table 1). These results were also calculated based on analyzing weather years 2012 to 2021 together with economic arbitrage dispatch method. Due to the winter season load characteristics, the ESRs, no matter how long their duration, were not found to have 100% accreditation even at the 1,000MW installation level. In addition, Figure 4 illustrated the ELCC accreditation being inversely proportional to ESR penetration, as did with the summer seasonFigure 4: 2022 Aggregated Winter ESR ELCC Accreditation. The overall ELCC for 4-hour ESR decreased from 83% to 51%, 6-hour ESR decreased from 83% to 58%, and 8-hour ESR decreased from 89% to 61% for the range of installations of 1,000MW-5,000MW. Full table of winter season results are shown in Table 4 below.

Table 4: Winter ELCC Accreditation of 4-hour, 6-hour, and 8-hour ESR

Duration \ Capacity	1,000 MW	3,000 MW	5,000 MW
4-hour	83%	71%	51%
6-hour	83%	79%	58%
8-hour	89%	82%	61%

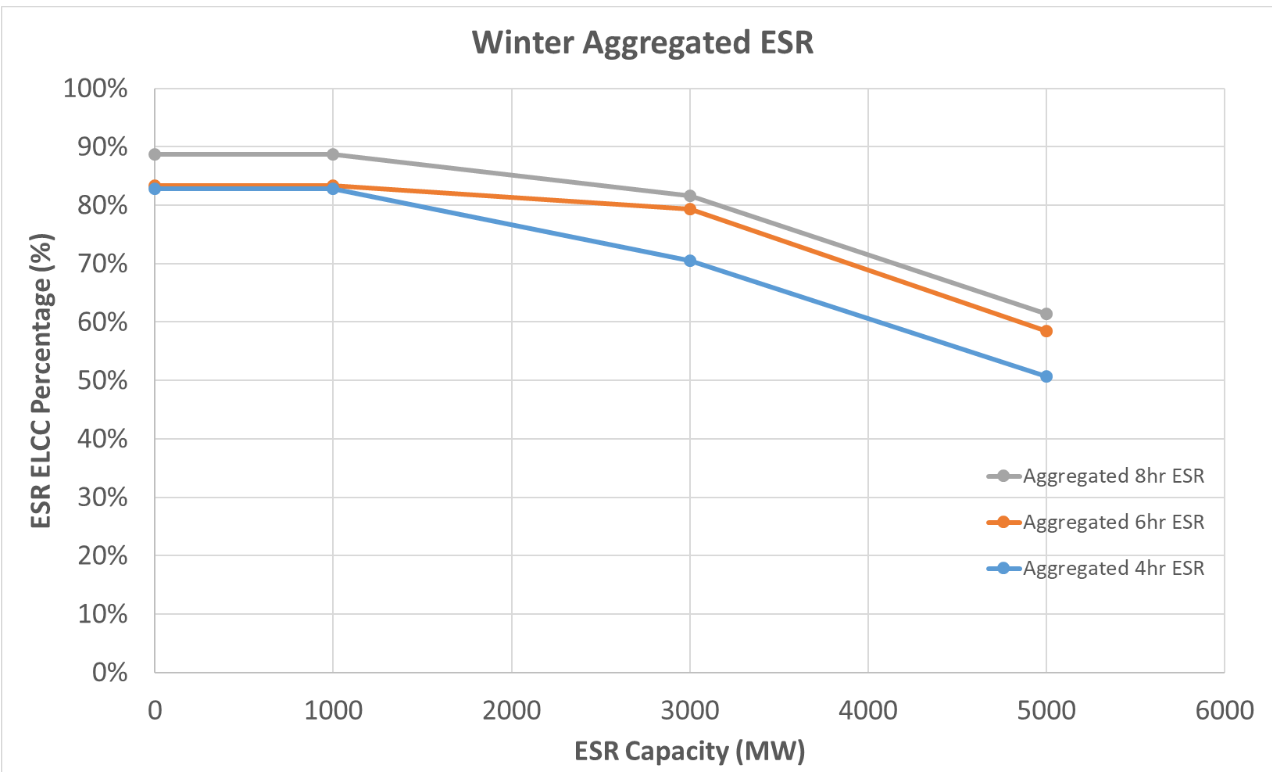

Figure 4: 2022 Aggregated Winter ESR ELCC Accreditation

2.8 ALLOCATION

The results of this study establish the 4-hour, 6-hour, and 8-hour ELCC curves that are currently scheduled to be used for the 2023 ESR ELCC allocation process, applied to the 2024 Resource Adequacy Workbook submissions outlined in Attachment AA of the SPP Tariff. Then, the once every two years, the ESR ELCC study will be performed, next in 2024, or sooner as directed by the SPP governing bodies, to update the ELCC curves. Per the requirements of the SPP Planning Criteria, the allocation and posting of existing ESR resources will be completed by October 1 of every year, along with the wind and solar ELCC allocation results for each individual resource. If the methodology of the ESR ELCC analysis changes, then an additional ESR study will be performed prior to the allocation of ESR accreditation (October 1, 2023), under the discretion of the SAWG.

Based on the results of the study, the total penetration of ESRs will dictate the percentage of accreditation that all ESRs will receive based on each tier and duration, regardless of location of the resource. Annually, each allocation cycle will be based on the most recent ELCC ESR study results. During the allocation process, eight-hour equipment will be allocated first and then each additional hourly duration studied resource will build upon the prior one. Resources in Tier 1 will be prioritized over resources in Tier 2 throughout the allocation process when determining the resource's accredited capacity. Facilities which do not meet the hourly duration timeframe studied will be rounded down to the nearest hourly duration. Based on the four-hour minimum continuous time duration requirement, two-hour ESRs would receive accreditation on the four-hour curve based on the penetration level and would receive no more than 50% accreditation. The penetration for each allocation tier and duration will build upon the prior one when determining the accreditation of resources for that given tier and duration. Below is the order that ELCC will be allocated for existing ESRs in SPP.

1) ESR with eight (8) Hour rating meeting Tier 1 requirements
2) ESR with six (6) Hour rating meeting Tier 1 requirements
3) ESR with four (4) Hour rating meeting Tier 1 requirements
4) ESR with eight (8) Hour rating meeting Tier 2 requirements
5) ESR with six (6) Hour rating meeting Tier 2 requirements
6) ESR with four (4) Hour rating meeting Tier 2 requirements

CONCLUSION

The purpose of ELCC is to accurately estimate the value of energy storage resources relied upon to meet system capacity needs for Resource Adequacy purposes. Consistent with approved policy, business practices, and criteria, SPP performed an ELCC ESR analysis for summer and winter seasons. For the summer season, the overall ELCC accreditations for 4-hour ESR were 100% (1,000MW), 96% (3,000MW), and 84% (5,000 MW). For 6-hour ESR, the ELCC accreditations were 100% (1,000MW), 98% (3,000MW), and 95% (5,000 MW). Eight-hour ESR accreditations were 100% (1,000 MW), 97% (3,000MW), and 96% (5,000MW). For the winter season, the overall ELCC accreditations for 4-hour ESR were 83% (1,000MW), 71% (3,000MW), and 51% (5,000 MW). For 6-hour ESR, the ELCC accreditations were 83% (1,000MW), 79% (3,000MW), and 58% (5,000 MW). Eight-hour ESR accreditations were 89% (1,000 MW), 82% (3,000MW), and 61% (5,000MW). Results from this study establish the ELCC ESR curves for 4-hour, 6-hour, and 8-hour duration resources until the next ESR ELCC study is conducted.

APPENDIX A: LIST OF ACRONYMS

BA	Balancing Authority
ELCC	Effective Load Carrying Capability
ESR	Energy Storage Resource
ISO	Independent System Operator
LFU	Load Forecast Uncertainty
LOLE	Loss of Load Expectation
LOLP	Loss of Load Probability
LRE	Load Responsible Entity
MW	Megawatt
Tariff	Open Access Transmission Tariff
RTO	Regional Transmission Organization
SAWG	Supply Adequacy Working Group
SERVM	Strategic Energy & Risk Valuation Model
SPP	Southwest Power Pool