The Capacity Accreditation of Demand Response in SPP

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Energy+Environmental Economics

Authors & Acknowledgements

Project Team

Energy and Environmental Economics, Inc. (E3) is a leading economic consultancy focused on the clean energy transition. For over 30 years, E3's analysis has been utilized by the utilities, regulators, developers, and advocates that are writing the script for the clean energy transition in leading-edge jurisdictions such as California, New York, Hawaii and elsewhere. E3 has offices in San Francisco, Boston, New York, Denver, and Calgary.

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Table of Contents

Executive Summary

The Southwest Power Pool (SPP) is undergoing significant changes, driven by a transformation in generation mix, scheduled fossil retirements, extreme weather events like Winter Storm Uri in 2021, and growing electricity demand from data centers and other large loads. These dynamics have revealed increasing resource adequacy (RA) risks that occur outside of traditional Summer peak periods. In response, SPP has updated its planning reserve margin (PRM) requirements, prompting Load Responsible Entities (LREs) to procure new resources to meet the new Winter resource adequacy requirement in addition to their existing Summer obligations. Like many other power markets, the SPP also faces challenges in interconnection timelines and developers face supply chain constraints for new development. These issues continue to pose risk to meeting the system's near-term reliability needs.

New loads coming online is part of SPP's growing resource adequacy need but is also a potential source of system flexibility. As with most US electricity markets today, data centers and other large loads represent the largest component of near-term load growth. In the longer term, drivers of load growth may also include electrification of transportation, buildings, and industrial processes. To help integrate this unprecedented demand, the industry is exploring whether data centers and other large loads can use load flexibility to defer some of the incremental resource adequacy need.[1]

This paper looks to further the industry's understanding of the capacity accreditation of demand response (DR) within an established capacity market framework for Independent System Operators (ISOs)/Regional Transmission Operators (RTOs). Specifically, this study focuses on calculating DR capacity accreditation under an **Effective Load Carrying Capability (ELCC)** framework within the SPP capacity market design and aims to answer the following key questions:

+ What is the ELCC based capacity accreditation value of DR in SPP?
+ Which DR parameters (duration, number of hours available, and total available curtailable load) have the largest impact on its capacity accreditation in SPP?
+ How often and at what times should DR be expected to be called to achieve high capacity accreditation?

This paper evaluates DR under different scenarios using RECAP,[2] E3's loss-of-load-probability (LOLP) model that has been used across North America to answer similar questions. We simulated the SPP market within RECAP to determine critical hours within the Summer and Winter seasons, as the first step toward determining the capacity accreditation of DR. SPP's critical hours occur both in the Summer and the Winter periods, during the abnormally hot or cold periods with high loads and low resource availability. In the Summer, heat waves lead to higher-than-normal cooling demands in the afternoon, but electricity demand falls as the region cools at night. This results in Summer critical

[1] For example see some recent articles on data center DR: How Data Centers Can Set the Stage for Larger Loads to Come - RMI, Existing US grid can handle 'significant' new flexible load: report | Utility Dive, Internet data centers participating in demand response: A comprehensive review - ScienceDirect

[2] E3's RECAP Model: RECAP - E3, and documentation applicable to this study: RECAP-Documentation.pdf

hours during the afternoon lasting 2-6 hours, with critical hours occurring in several consecutive days. On the other hand, cold snaps often last longer than 6 hours. Heating demand may even persist across multiple days, leading to multi-hour or multi-day periods of consecutive critical hours in Winter. The ability to meet demand during these critical hours across both seasons impacts all resources' capacity accreditation, including that of DR.

This study uses SPP's definition of ELCC as the metric to quantify DR capacity accreditation. SPP currently uses ELCC to accredit variable resources (wind and solar) and battery storage. Increasingly, markets and planners use the ELCC as a method to calculate the capacity accreditation of intermittent and energy-limited resources, to reflect their performance during system critical hours. ELCC captures the interactions of increasing penetrations of the same resource and the interactions between other resources within the portfolio, which makes it useful to measure the changing accreditation of DR in this study.[3]

Quantifying DR's Capacity Accreditation in SPP

To evaluate the capacity accreditation of DR in SPP, we quantify DR's ELCC across a suite of scenarios. These scenarios are designed to provide insight into the impact that key parameters have on DR's capacity accreditation within the SPP system. The scenarios test duration, calls, and penetration of total available curtailable load for the Summer and Winter season across two test years, 2025 and 2030.[4]

Table 1: Eight Study Scenarios

Duration	Seasonal Call Limit	Penetration	Scenario Description
4 hours	40 hours/season	2 GW	Approximates the current level of DR adoption and duration
4 hours	40 hours/season	4 GW	Tests moderate DR growth and entry of new large loads
4 hours	40 hours/season	6 GW	Bookend scenario of high DR entry
4 hours	No Seasonal Call Limit	6 GW	Designed to understand the impact of adding more call hours with high saturation
10 hours	100 hours/season	2 GW	Approximates current levels of DR adoption and tests the value of longer duration
10 hours	100 hours/season	4 GW	Tests moderate DR growth and the value of longer duration
10 hours	100 hours/season	6 GW	Bookend scenario of high DR entry and duration
10 hours	No Seasonal Call Limit	6 GW	Designed to estimate the impact of adding more call hours under high DR saturation

[3] For more detail on ELCC and its application to markets, see E3's 2025 paper *Resource Adequacy for the Energy Transition: A Critical hours Reliability Framework and its Applications in Planning and Markets* and 2020 paper *Capacity and Reliability Planning in the Era of Decarbonization.*

[4] E3 defines total available curtailable load as the total MW available to be curtailed by the market operator

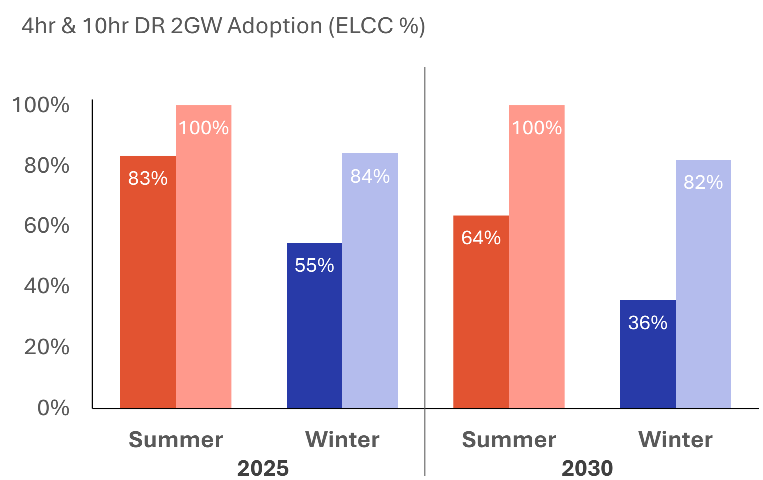
The results of the scenarios from Table 1 revealed the following insights:

- **Call Duration:** Extending event lengths from four to ten hours increases ELCC materially, with the largest increase in capacity accreditation in the Winter.
- **Call Limits:** Increasing call limits increases ELCCs only under high penetrations of DR.
- **DR Penetration:** First 2 GW of DR yields high capacity accreditation, but with increasing DR penetration, saturation effects emerge.
- **Critical Hours:** Across simulations in this study, SPP Summer exhibits critical hour periods lasting 3-5 hours whereas Winter critical hour periods often exceed 10 hours. DR has accordingly higher ELCCs in Summer than Winter.[5]
- **Portfolio Composition:** DR ELCCs are positively influenced by increasing renewables penetration due to diversity benefits but negatively impacted by competition from other energy limited resources (ELRs) like battery storage.

Call Duration

Four-hour DR has a Summer ELCC of 83% and 64% in 2025 and 2030 respectively, and a Winter ELCC of 55% and 36% in 2025 and 2030 respectively. Ten-hour DR achieves higher ELCCs than four-hour, 100% ELCC in the Summer for 2025 and 2030, and between 82% and 84% ELCC in the Winter from 2025-2030. These ELCC findings highlight the impact that duration has on capacity accreditation in the SPP. They also highlight the seasonal impact of accreditation as both four- and ten-hour DR perform well during concentrated Summer afternoon risk windows, while ten-hour DR provides much more reliability benefits during multi-day cold snaps that drive extended loss-of-load conditions in the Winter.

Figure 1: SPP DR ELCC Results with Seasonal Call Limits at 2GW Adoption

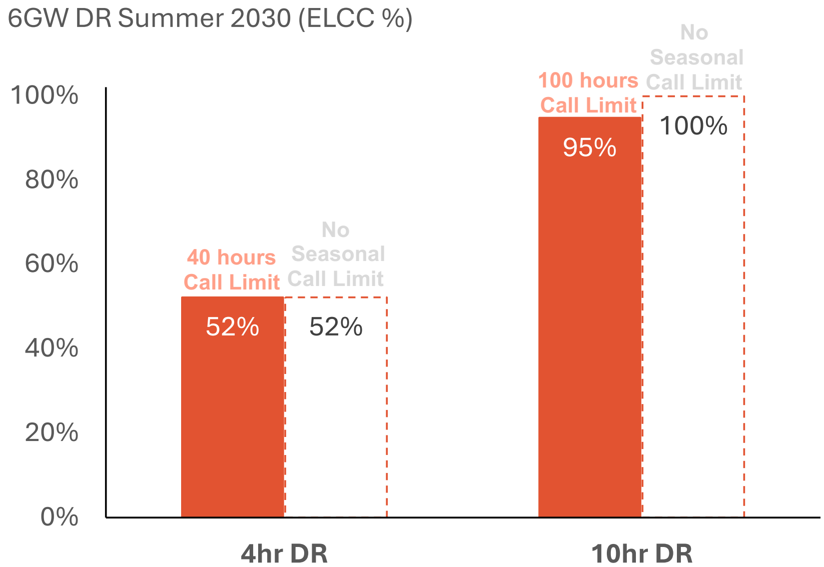


[5] SPP Summer season is June 1 – September 30, Winter season is December 1 – March 31. Shoulder months do not have resource adequacy requirements in SPP.

Call Limits

Under high penetrations of DR, the ELCC results highlight saturation effects, and the impact of increasing call hours under high DR adoption. In 2030 with ten-hour duration, at 6GW of penetration, increasing the call limit increased capacity accreditation by 5%.

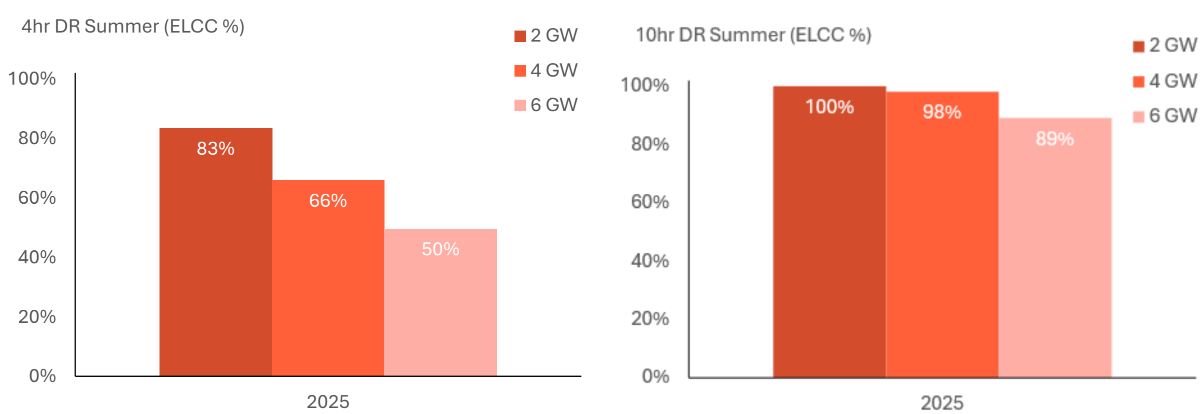
Figure 2: Impact of Seasonal Call Limits Under High DR Penetration



DR Saturation

With respect to the impact of saturation, four-hour DR saw stronger saturation effects than ten-hour. In 2025 four-hour ELCCs decline from 83% to 50% as penetration moves from 2GW-6GW. Ten-hour is more resilient to saturation effects and only declines by 11%.

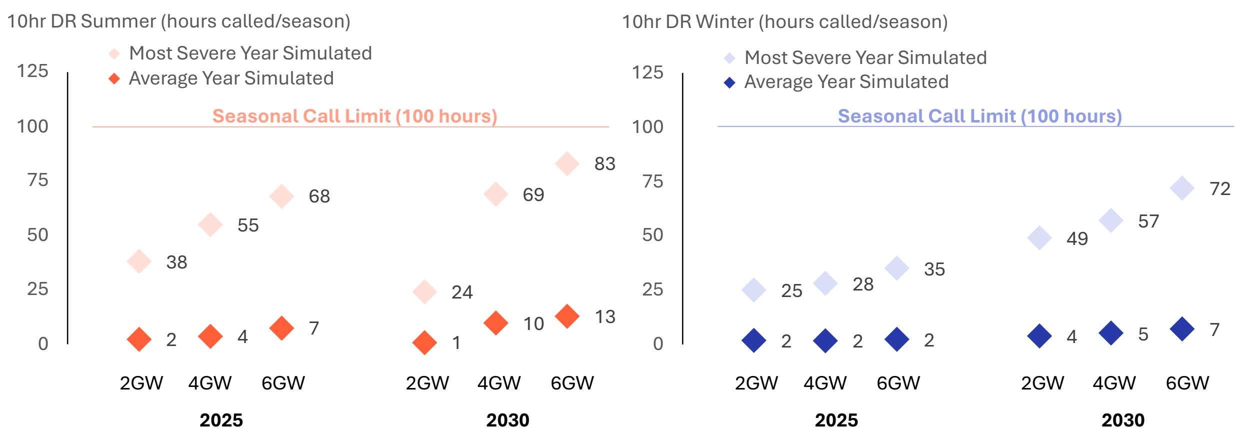
Figure 3: Saturation Effects of DR ELCCs



Critical Hours Required

To achieve these ELCC results, DR requires only limited hours of response. Across the weather years and forced outage simulations in this study, an ***average*** of 10 hours of DR is required across the year to achieve the ELCCs described above. Further, under the most severe Winter event observed in the LOLP model, 72 hours are needed across the season to achieve an 82% ELCC for ten-hour DR. During the hottest Summer observed in the LOLP model, 83 hours are needed across the season to achieve 100% ELCC again on ten-hour duration DR. Figure 4 below highlights the max and average number of hours required across both study years for each duration tested for ten-hour DR.

Figure 4: Total Hours DR is Called by Season (Ten-Hour DR with 100 Hour Seasonal Call Limit, Average vs. Most Severe Simulated Year)



Portfolio Composition

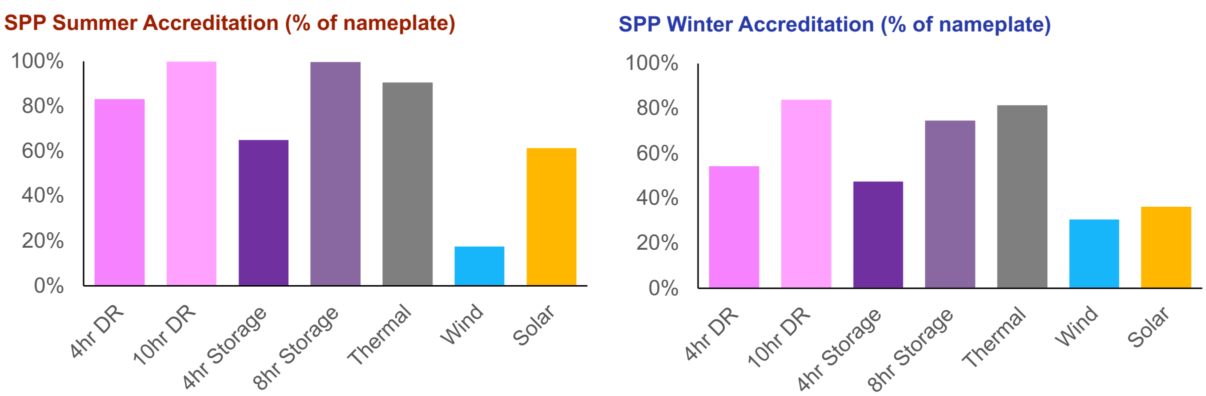
Similar to other ELRs like battery storage, the value of DR also depends on the portfolio mix, specifically if the presence of variable resources shortens or lengthens the critical hours. Moving from 2025-2030 our forecast of the SPP portfolio sees several changes, which is a key driver of DR ELCCs. From 2025-2030, E3's forecast includes 13GW of wind additions, 2GW of solar additions, 5GW of four-hour battery storage additions, and 4GW of gas additions. The forecast also includes 3GW of coal retirements. DR ELCCs decline from 2025-2030, indicating a net negative impact from the saturation of ELRs due to increased battery storage, which outweigh the diversity benefits of increased wind and solar.[6]

[6] For more information in diversity benefits and saturation effects see these again see these E3 papers: *Resource Adequacy for the Energy Transition: A Critical hours Reliability Framework and its Applications in Planning and Markets* and *Capacity and Reliability Planning in the Era of Decarbonization.*

DR Has Comparable ELCCs to Other Supply Resources

Both four-hour and ten-hour DR achieve capacity accreditation on par with traditional supply-side resources. DR shares similar dispatchable characteristics to storage and even gas peakers, giving operators one additional resource to balance load during critical hours. Figure 5 shows the achieved DR ELCCs measured in this study and the SPP capacity accreditation of multiple resource classes. When appropriately accredited, DR under these parameters can give system planners and operators another resource to meet near- and long-term resource adequacy needs. Given the current delays in development of supply-side resources, this makes DR a potentially faster solution for facilitating load growth and mitigating near-term resource adequacy risks.

Figure 5: Comparison of 2025 Capacity Accreditation Values by Resource*



* DR accreditations are E3's 2025 RECAP ELCC results (2GW adoption, 40hrs/yr for four-hour DR, 100hrs/yr for ten-hour DR). Storage, Wind, and Solar accreditations are Tier 1 ELCCs from SPP's 2024 ELCC study. Thermal accreditation is conventional fleet average ACAP from SPP's 2025 ACAP informational posting.

Conclusion

When appropriately accredited, DR can be just as valuable as any other resource in meeting resource adequacy needs. In the SPP, four-hour DR achieves a 55-83% ELCC and ten-hour DR achieves an 84-100% ELCC across seasons in 2025. This requires an average of ten hours of dispatch per year, and no more than 83 hours across the most severe Winter and Summer observed. Removing the seasonal call limit to DR does not increase its ELCC unless under very high DR adoption. In contrast, extending the duration capability of each call does increase ELCCs. As DR penetration increases, so does the length of critical hours, making shorter duration DR less effective. In the near-term, ten-hour DR ELCC stays above 80% even when testing the high adoption scenario of 6GW of DR. With appropriate accreditation and market design, SPP can encourage load flexibility and provide dependable capacity even with limits on how often the DR can be called. DR supports a balanced path for SPP: maintaining near-term reliability while long-term transmission and clean generation investments advance.

For DR to be fully integrated into SPP's capacity framework:

- Accreditation should be dependent on the program parameters, tied to availability and delivery during critical periods, aligning DR with storage and renewables.
- Market products must evolve with market needs. This means calculating an appropriate capacity accreditation for different classes or parameters of DR. For example, quantifying the number of well-timed events required to achieve high ELCC, rather than unlimited seasonal hours.
- DR can provide additional resources for LREs navigating rapid demand growth, enabling new loads before utility-scale resources can come online.

Introduction

SPP, like many other U.S. markets, is experiencing a period of rapid and unprecedented change. This change is driven by increases in electricity demand, further adoption of renewables and energy storage, ongoing thermal generation retirements, shifting weather patterns, and transmission system constraints. To navigate these challenges and uncertainties, SPP has launched a range of initiatives aimed at strengthening reliability, optimizing resource utilization, and expanding market access for both load and generation. Current initiatives include:

+ Large Load Integration
    - High-Impact Large Load (HILL) integration (RR696). New processes to interconnect and operate very large, fast-growing loads (e.g., data centers),[7] including the Conditional High-Impact Large Load (CHILL) pathway that enables faster interconnection for interruptible large loads.
+ SPP's Changes to RA
    - FERC-accepted Base PRM increases from 15% to 16% for Summer 2026, and a new Winter PRM of 36% for 2026/2027, followed by a planned 2029 increase to 17% (Summer) and 38% (Winter).[8] This corresponds to an ACAP PRM of 7% for Summer 2026 and 15% in Winter 2026/2027.
+ Performance-Based DR Accreditation
    - SPP proposed shifting its DR framework from the current enrollment-based accreditation system to a performance-based accreditation model.[9]
+ Western Expansion/Markets+
    - FERC-approved Markets+ tariff and funded Phase 2 implementation for SPP's Western day-ahead/real-time market; broader RTO expansion to increase reliability and efficiency of dispatch in SPP.[10]
+ Transmission System Planning and Investment
    - Historic $7.7B 2024 ITP portfolio approval including large bulk system investments, short-term reliability projects, and coordination born out of Holistic Integrated Tariff Team (HITT) recommendations.[11]

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7 High Impact Large Load (HILL) Integration - Southwest Power Pool
8 SPP board approves new planning reserve margins to protect against high Winter, Summer use - Southwest Power Pool
9 SPP Documents & Filings - Southwest Power Pool
10 SUF Monthly Update
11 2024-itp-assessment-report-v10.pdf

With growing interest from data centers and other large loads in SPP, alongside the introduction of the CHILL/HILL process and evolving RA requirements, this paper examines the role DR can play as the market undergoes significant transformation.

Today, SPP uses a load modifier regime in its RA framework that includes about 1.6 GW of DR from interruptible/curtailable and non-dispatchable programs, typically supplied by utilities and cooperatives with existing DR/interruptible rate customers. SPP recently proposed a performance-based accreditation for DR, which means only DR resources that can meet reliability/response performance metrics will be counted toward RA. Further, the CHILL pathway is designed to bring in large loads (like data centers and industrial/advanced manufacturing) that are willing to accept potential load-shedding or curtailment during system stress to connect more quickly. This combination of performance-based DR in combination with CHILL providers could broaden the pool of DR providers beyond traditional interruptible rate customers to large commercial/industrial loads and possibly aggregators with strong response performance.

Building on these recent developments in DR in SPP, in this white paper, we assess the reliability contribution of DR in the SPP market. Using E3's SPP outlook as a baseline portfolio, we estimate the ELCC of DR to quantify its capacity accreditation. Our analysis evaluates multiple DR configurations, including variations in response duration and adoption levels. These different configurations illuminate what parameters are most important for strong DR contributions to RA.

The structure of this paper is as follows:

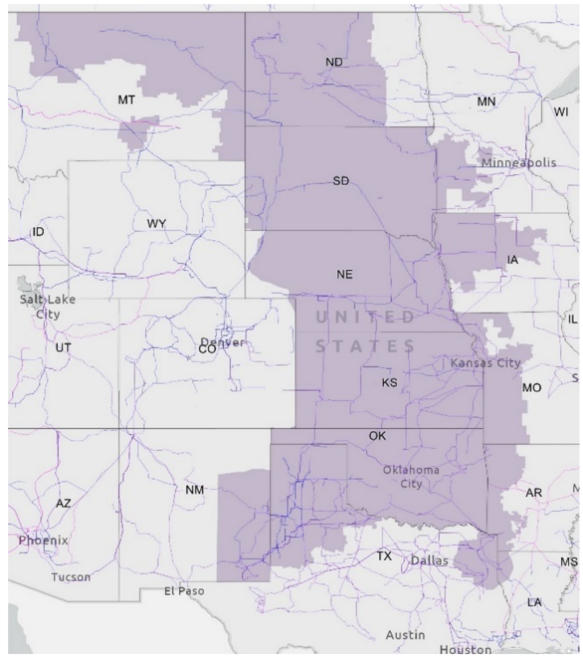
+ **Section 1:** Background on the SPP market and the current state of DR
+ **Section 2:** Capacity accreditation of DR, with ELCC results across DR configurations and scenarios
+ **Section 3:** Comparison of DR ELCC and other resources
+ **Section 4:** Conclusions

SPP Background

SPP is a regional transmission organization (RTO) that coordinates the reliable operation of the bulk electric system and wholesale electricity markets. SPP's footprint in the Eastern Interconnection spans 14 states across the central United States, from the Canadian border to Texas and Louisiana, serving over 17 million people within a 545,000 square mile area.

SPP's extensive high-voltage transmission network enables power flows across the region and with neighboring systems, supporting both reliability and market operations. SPP administers day-ahead and real-time energy markets, as well as transmission congestion management and ancillary services. SPP also is responsible for regional transmission planning, ensuring that investments in the grid support long-term reliability, economic efficiency, and integration of diverse energy resources.

Figure 6: SPP Footprint



Energy Transition in SPP

SPP has an all-time Summer peak demand of 56 GW occurring in 2023 and saw an annual 2024 energy consumption of approximately 278 TWh.

The region is distinguished by its industry-leading wind resources, with a current peak wind output of 24 GW from approximately 35 GW of installed capacity. Alongside wind, SPP relies on a diverse generation mix that includes 22 GW of coal, 36 GW of natural gas-fired generation, and smaller contributions from nuclear (2 GW), oil-fired (2 GW), and hydroelectric (3 GW) resources. While solar and battery storage currently make up a small portion of the SPP resource mix, their capacity is expected to grow significantly in the coming years.

In 2024, wind generation supplied 38% of SPP's total energy, making it the single largest contributor to the mix. Natural gas followed with 29%, while coal accounted for 24%. Nuclear and hydro combined provided 7%, with the remaining 2% coming from solar, oil-fired units, and other sources.[12]

[12] 2024_Seasonal_state_of_the_market_report.pdf

Figure 7: SPP 2024 Installed Capacity

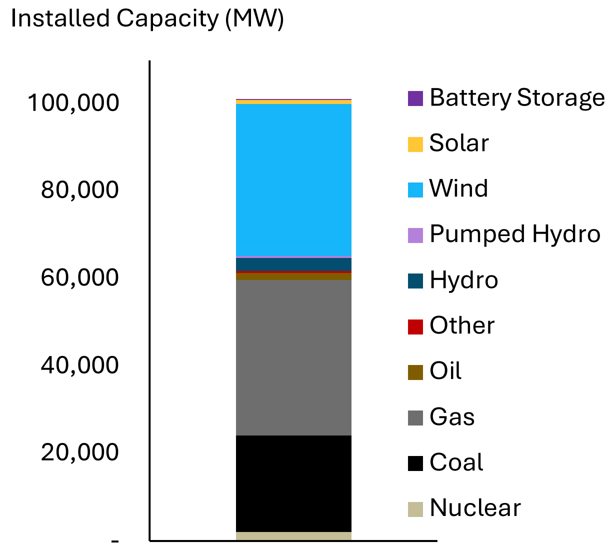
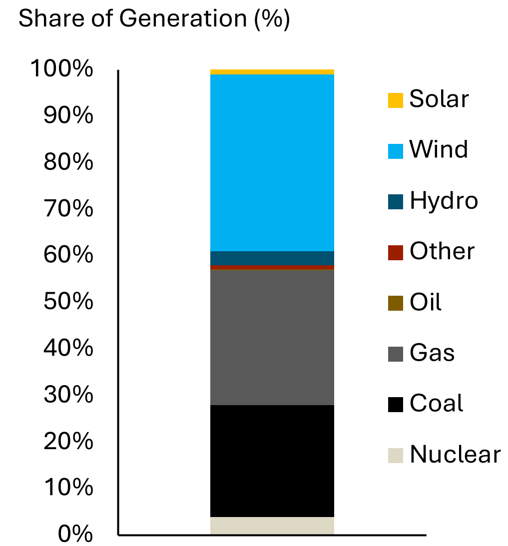
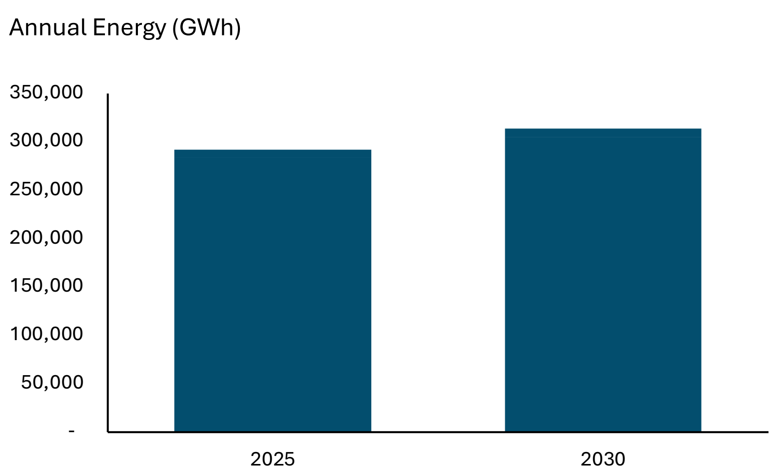


Figure 8: SPP 2024 Energy Production



To estimate the ELCC value of DR, we rely on our SPP market price forecast for its load and supply portfolio.[13] This outlook projects a 4% increase in both annual energy demand and peak load between 2025 and 2030, with peak demand reaching 61 GW by 2030.[14]

Figure 9: E3 Forecast of SPP Load Growth



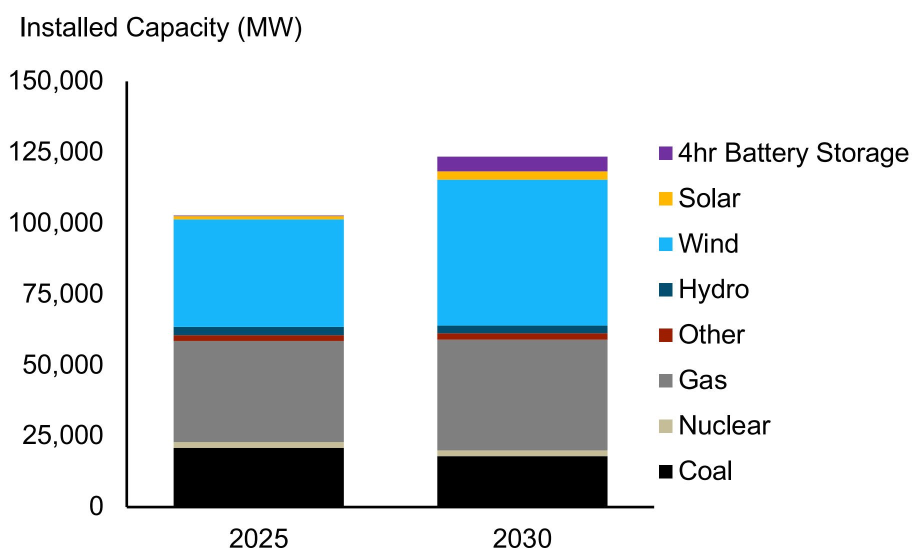
From 2025-2030, our outlook utilizes information from utility IRPs and SPP's interconnection queue to forecast near-term capacity additions, leveraging late-stage projects. We then combine the utility's long-term IRP results with our own long-term expansion model for generation 2030+ based

[13] More information on our SPP market forecast: [SPP Price Forecast – 2025 Edition – Core Case | Energy + Environmental Economics]

[14] E3's 2025 load outlook assumes near-term datacenter growth, stabilizing through 2030.

on our view of gas prices, load, state policy, PRM requirements, and resource costs to forecast the generation that will meet load. The figure below shows the capacity portfolio utilized in the simulations from our off-the-shelf view. The forecast sees increases in wind generation, along with gas additions to meet load growth and offset coal retirements. We also forecast energy storage adoption in 2030, with solar investment also contributing.[15]

Figure 10: E3 2025-2030 Forecast of SPP Resource Portfolio



SPP RA Market

Unlike the centralized capacity markets in PJM or ISO-NE, SPP's RA framework is a requirement within its open access transmission tariff. Each Load Responsible Entity (LRE) in SPP must demonstrate, via seasonal RA Workbooks submissions, that it holds enough accredited capacity to meet its forecasted Net Peak Demand plus an ACAP PRM requirement.

While SPP does not clear a centralized RA auction, LREs face deficiency charges if they cannot demonstrate compliance, creating an incentive to secure capacity. This makes SPP's RA system a bilateral, self-supply model where utilities and other entities balance their portfolios through a mix of owned generation, firm power purchases, and increasingly, qualifying demand response programs.

The SPP RA market has been undergoing several design changes, impacting both how LRE capacity obligations are determined and how resources are accredited. SPP's recently adopted ACAP PRM is 7% for the Summer Season and 15% for the Winter Season.[16] Currently, each LRE's "Net Peak Demand" is their seasonal Non-Coincident Peak (NCP) load reduced by qualifying DR programs, firm

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[15] For more information on our resource cost forecasts and how this incorporates recent trends in tariffs and tax credits please see our RECOST model: [E3 Forecasts Higher Resource Costs Under 2025 Policy in Q3 RECOST Update - E3]

[16] Corresponds to Base PRMs of 16% in Summer and 36% in Winter: [ACAP PRM – 2025 Informational]

imports, and other load modifiers. This process treats DR as a load modifier rather than an accredited resource. The following section explains how supply-side resources are accredited in SPP, and how this framework can be applied to DR.

SPP Capacity Accreditation

SPP uses different methods to determine the accredited capacity of resources for its RA framework. For variable resources like wind and solar, and for battery energy storage, SPP determines accreditation through annual ELCC studies. For conventional resources like natural gas and coal-fired plants, SPP recently introduced a performance-based accreditation model. This methodology is based on a resource's demonstrated net generating capability and its historical performance, including its equivalent forced outage rate on demand (EFORd), which measures how often a resource is forced offline when needed.[17] Hydro resources are accredited according to firm capacity obligations and historical performance, while external imports receive accreditation only when they're backed by firm contracts.

SPP's annual ELCC studies determine seasonal capacity accreditation for wind, solar, and battery storage. The studies use probabilistic LOLP modeling to determine the resource-class ELCCs for the upcoming delivery seasons.[18] ELCC studies are repeated annually since results are dependent on SPP's resource portfolio mix and load. Wind and solar are accredited through a tiered framework: Tier 1 for resources with firm transmission service and Tier 2 for all others. The ELCC value of each resource Tier is allocated across the fleet of registered resources based on each registered resource's performance during SPP's highest 3% of net-load hours. Storage accreditation is differentiated by both duration and Tier. For example, eight-hour storage can approach 100% accreditation, while four-hour has lower values (~65% in Summer, <50% in Winter).

Recent discussions within the SPP working group, as documented in Supply Adequacy Working Group (SAWG) minutes and scope documents, show active efforts to refine how DR is considered. In the July 2025 session, SPP proposed a new DR framework to establish an accreditation structure that integrates DR into RA on the same footing as generation, moving away from simply deducting DR from load forecasts. The framework creates two primary categories: Market Registered DR (MRDR), which participates fully in the Integrated Marketplace and is deployed economically like supply resources, and Reliability Registered DR (RRDR), which is deployed only during conservative operations or energy emergencies to support grid reliability. Both MRDR and RRDR require registration, seasonal capability and operational testing, and performance-based accreditation using lookback periods and event-hour measurements.[19]

These DR efforts are also being considered in alignment with new large-load and HILL and CHILL policies. Specifically, CHILL offers large-load customers a faster interconnection path, with the trade-off of potential temporary curtailments, in exchange for expedited study results that allow

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[17] FUEL ASSURANCE AND ACAP PRM OVERVIEW
[18] SPP 2025 ELCC Study Scope
[19] SPP Documents & Filings - SAWG Meeting Materials

them to integrate and operate as quickly as possible.[20] Interconnecting as a CHILL currently appears to have the CHILL counted like DR in RA planning, but it does not auto-enroll the load as a market DR resource.

Table 2: SPP Current Capacity Accreditation

Resource Type	Accreditation Method	2024-2025 Accreditation (% of nameplate capacity)[21]
Gas, Coal, Nuclear	ACAP - Installed capacity minus equivalent forced outage rates on demand (EFORd) & adjusted equivalent forced outage factor (EFOF)[22]	91% (Summer), 82% (Winter)
Hydro	Firm capacity obligations	100% of capacity obligation
Wind	ELCC by Tier, Tier 1 (with firm TX) & Tier 2 (without)	18% (Summer), 31% (Winter)
Solar	ELCC by Tier, Tier 1 (with firm TX) & Tier 2 (without)	62% (Summer), 37% (Winter)
Battery Storage	ELCC by duration (4hr, 6hr, 8hr) and by Tier	4hr: 65% (Summer), 48% (Winter) 6hr: 94%(Summer), 75% (Winter) 8hr: 100%(Summer), 75% (Winter)

Demand Response (DR)

What is DR?

DR encompasses a range of approaches that differ in how they reduce or reshape electricity demand during periods of system stress. DR is the most traditional form, where participating loads, such as industrial facilities, commercial buildings, or aggregated residential demand, are curtailed outright during an event, lowering system load in real time (curtailed DR). Shift DR instead moves consumption from critical periods to lower-risk periods, for example by pre-cooling buildings in the afternoon before a Summer peak or shifting EV charging to overnight hours. Other forms include shape DR, which permanently modifies load profiles through smart appliances or pricing signals. Together, these DR types provide different durations, magnitudes, and response speeds, allowing them to complement supply-side resources and enhance system reliability. **This study specifically looks at the capacity accreditation of curtailed *DR* programs in SPP.**

DR in SPP

DR in SPP is currently concentrated among large industrial and commercial users. These participants often operate under interruptible tariffs or direct load control agreements with their LREs. The most common participants include industrial manufacturing facilities, pulp and paper mills, chemical processors, agricultural pumping loads, and municipal water treatment systems.

[20] High Impact Large Load (HILL) Integration

[21] Accreditation values shown for aggregate SPP resource class, prior to allocation of accreditation to individual SPP-registered resources.

[22] SPP thermal resources are accredited with net generating capability under Base PRM accounting. Thermal resources receive ACAP values under ACAP PRM accounting, as part of Performance Based Accreditation revisions. For ELCC resources, the same values are used under both Base PRM and ACAP PRM accounting.

These large-scale participants can reduce load anywhere from tens to hundreds of megawatts with relatively short notice, providing significant support to the grid during critical hours. Programs are often structured for four-hour durations, which aligns with SPP's resource adequacy qualification requirements. However, many of these programs can accommodate longer durations when needed during extended peak demand periods or emergency conditions. As per SPP's 2025 Summer Resource Adequacy Report, LREs collectively reported ~1.6 GW of controllable and dispatchable DR, with a projected ~57% increase over the next five years.[23]

Table 3: Types of DR in SPP

DR Type	Accreditation Method	Utilization	Status[24]
Peak Demand DR Programs	Reduction in Load-Responsible Entity (LRE) Peak Demand Forecast	Typically called during EEA Events	Active
Market Registered DR Resource	ELCC + Energy Market Offer Curves	Economic dispatch into energy market, called before reliability registration	In development
Reliability Registered DR Resource *Focus of this paper*	ELCC	Called during SPP critical periods	In development

[23] SPP 2025 Summer Season RA Report
[24] Status as of September 2025

Capacity Accreditation of Demand Response

This section examines the capacity accreditation of DR in SPP using E3's resource adequacy modeling tool, RECAP. This study uses an ELCC methodology and aligns with SPP's definition of ELCC as the metric to quantify DR capacity accreditation. ELCC is the amount of perfectly reliable capacity (a "perfect capacity resource") that can be replaced by a given resource while maintaining the same system reliability standard. SPP currently uses ELCC to accredit variable (wind and solar) and battery storage.

We begin this section by describing the characteristics of the DR examined in this paper. Next, we characterize the distinct nature of loss-of-load events in SPP, which occur under different conditions in Summer versus Winter. We then present results from our ELCC analysis across a range of DR configurations and adoption levels. Finally, we summarize the findings and highlight the role of DR in supporting reliability during a period of rapid system change.

For this study, we modeled the SPP footprint as a single-zone system over 15 Monte-Carlo draws & 66 historical weather years (1954-2019). We modeled SPP's existing (2025) and 2030 system using assumptions from our 2025e SPP Market Price Forecast.

What Determines ELCC?

Any resource's capacity accreditation, and thus ELCC, is determined by the alignment between SPP's timing of critical hours and resource performance. To evaluate the reliability contribution of DR, we test multiple configurations that capture its operational limits and system interactions: duration, call limits, and penetration level.

SPP Critical Hours

While Summer critical hours have long defined reliability planning, recent history shows that extreme Winter weather events can be just as, if not more, disruptive. In February 2021, during Winter Storm Uri, SPP declared an Energy Emergency Alert 3 (EEA 3) and initiated controlled outages for the first time in its history as gas supply froze, wind output sagged, and demand surged. More recently, in December 2022 and January 2024, severe cold snaps again strained the system, with SPP relying heavily on imports and favorable wind conditions to avoid broader outages. These events underscore that SPP's reliability risks are not confined to peak Summer afternoons but span both seasons.

Generally, loss-of-load events in SPP emerge from a combination of severe weather, leading to higher than normal load conditions, and unexpected resource unavailability, leading to a lack of energy. These conditions are SPP's **critical hours**. Critical hours can happen any time of year but are typically categorized into seasonal critical hours. The heatmaps below show the critical periods in SPP as modeled in RECAP. These heatmaps represent the critical hours once SPP meets a 1-day-in-10-year loss of load expectation (or 0.1 LOLE) standard.

During the Summer, critical hours are concentrated in July and August and are most pronounced between hours 12-17. These periods coincide with higher cooling demand, lower than expected thermal availability, and lower than expected wind generation, resulting in a 4 to 5 hour window of risk. In 2030, the Summer loss-of-load hours widen and move later into the evening with higher adoption of solar. This creates an additional 3 to 4 hour window during and after sunset, an ideal scenario for energy limited resources like storage or demand response to be effective.

In the Winter, loss of load risk typically coincides with the most severe Winter days. Compared to Summer, the peak demand during the coldest days is typically much higher and longer, leading to an extended need for heating demand. Loss of load risk is therefore prevalent from the morning ramp-up until late in the evening. Cold snaps, wind droughts, and thermal forced outages pose a strong reliability risk for the entire Winter day.

Figure 11: SPP Summer Loss of Load Patterns

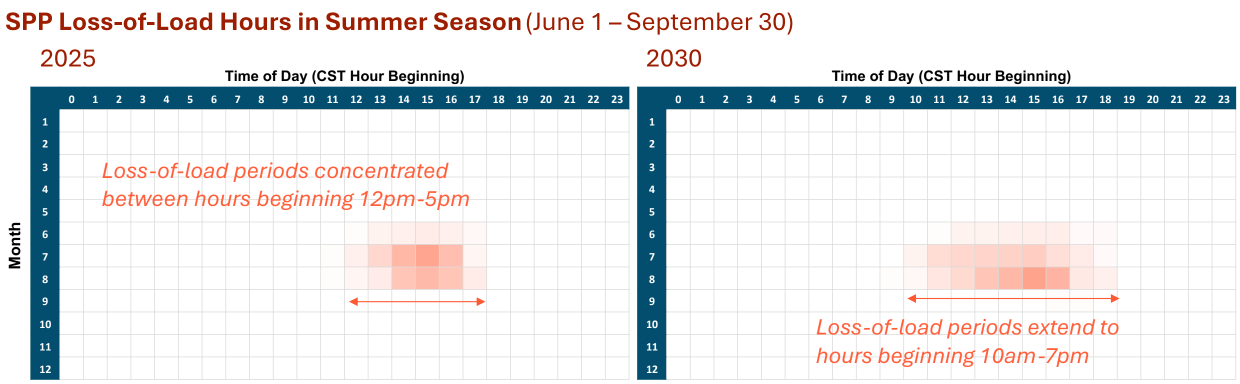
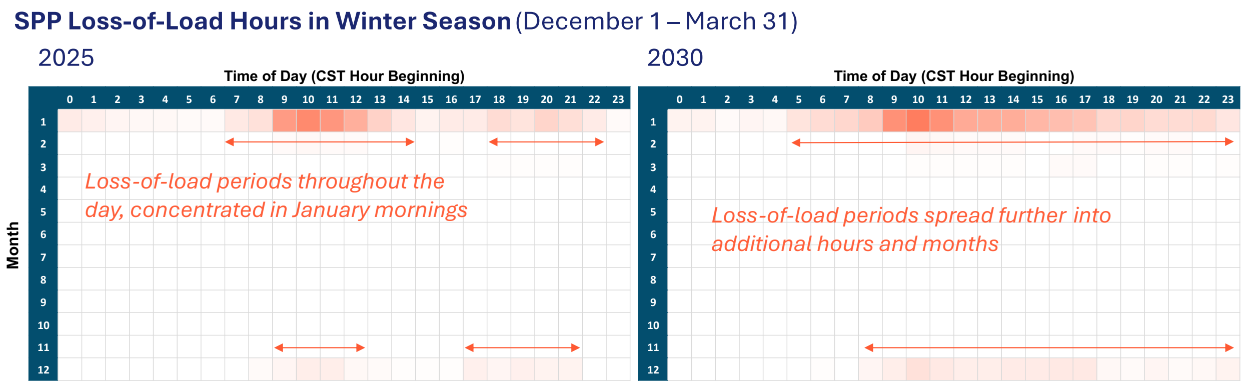


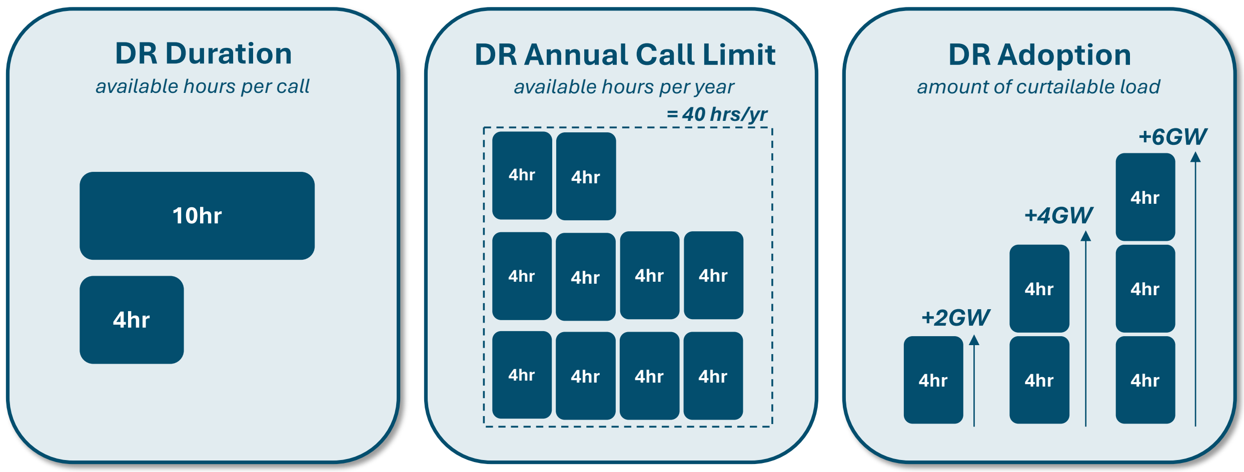
Figure 12: SPP Winter Loss of Load Patterns



DR Program Constraints and Availability During Critical Risk Periods

The capacity accreditation of DR is determined by three key parameters: DR duration, DR seasonal call limit, and DR adoption. DR duration is the maximum number of hours DR is available per call. DR calls are restricted to once per day. The DR seasonal call limit is the total number of hours per season that DR can be dispatched. Finally, DR adoption is the magnitude (measured in MW) of load that will respond to the DR call for its full duration. DR adoption may therefore be lower than the average or maximum magnitude of load associated with the DR providers. Only the fraction of load that is registered to respond in each SPP Season is counted. For example, a single SPP customer may have 500MW of average load but only register 200MW as DR in Summer and 100MW as DR in Winter. This study quantifies the ELCC of DR in SPP in 2025 and 2030 across a range of expected and bookend values for these three parameters.

Figure 13: Demand Response (DR) Program Parameters Explored in this Study



First, event duration is directionally linked to effectiveness: longer-duration DR can sustain support through extended loss-of-load periods, yielding higher ELCC values than shorter-duration programs.

Second, the number of allowable calls per season can matter: if a DR program commits to ten events but an eleventh is needed, DR provides no additional load reduction for the last event, reducing its effective contribution. Finally, like all energy-limited resources, DR experiences saturation effects as penetration increases—the incremental ELCC of each additional MW declines. Understanding these dynamics is essential for accurately quantifying DR's role in reducing loss-of-load risk and for designing programs that maximize its capacity accreditation. The following table outlines the suite of parameters tested:

Table 4: Range DR Operating Parameters & Adoption Levels Evaluated

DR Duration *Available Hours per day*	**DR Seasonal Call Limit** *Available Hours per season*	**DR Adoption Level** *Available GW*
4 hours	40 - 120	2 - 6 GW
10 hours	100 - 300	2 - 6 GW

Demand Response ELCCs

In this section, we demonstrate the results of our SPP LOLP modeling for DR. Specifically, we measure the ELCC of DR across different scenarios and configurations.

DR ELCCs

In 2025, four-hour DR with a 40 hours per season call limit achieves an 83% ELCC in the Summer and a 55% ELCC in the Winter. Ten-hour DR with a 100 hours per season call limit achieves a 100% ELCC in the Summer and 82% ELCC in the Winter. DR ELCCs change between 2025 and 2030 due to changes in SPP critical hours which are in turn due to changes in SPP's resource portfolio and load. SPP critical hours, resource portfolio forecasts, and load forecasts are in above sections. In 2030, four-hour DR with a 40 hours per season call limit achieves an 64% ELCC in the Summer and a 36% ELCC in the Winter. Ten-hour DR with a 100 hours per season call limit achieves a 100% ELCC in the Summer and 82% ELCC in the Winter. Under 2 GW of DR adoption, removing the seasonal call limit had no impact on the ELCC results in 2025 and 2030. DR duration is the most impactful parameter on DR ELCCs in both seasons and years, with ten-hour DR ELCCs receiving 27% to 28% higher ELCCs than four-hour DR at 2GW of DR adoption.

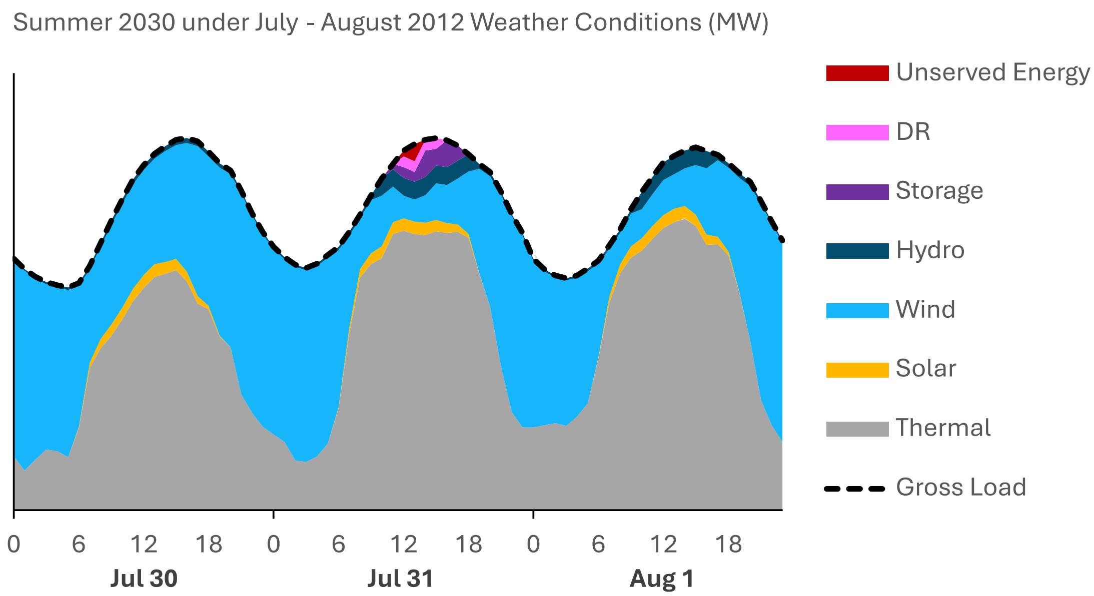
Figure 14: DR ELCCs by Duration and Seasonal Call Limit, 2GW of Adoption

The importance of seasonal call limits was evaluated by calculating DR ELCCs with and without the limit imposed. Figure 14: DR ELCCs by Duration and Seasonal Call Limit, 2GW of Adoption

above shows no difference in ELCC when the total calls per season are unlimited at the 2GW adoption level. This is primarily due to (1) the low frequency of critical hour periods occurring in any given year and (2) DR being limited to 1 call per day. Ten-hour DR receives higher ELCCs than four-hour DR in both seasons, revealing the importance of maximum duration capabilities in a single day. The seasonal call limit did not bind in any of the scenarios with 2GW of DR adoption, resulting in DR with no seasonal call limits having the exact same ELCC as DR with the seasonal call limits applied.

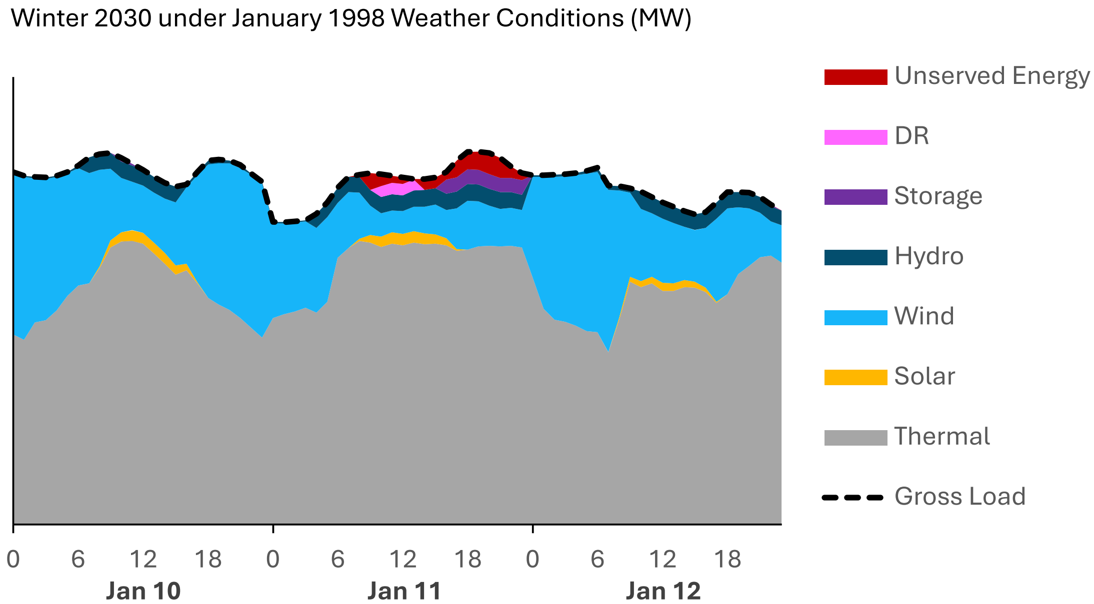
The dispatch plots below demonstrate examples of critical hours in Summer and Winter of 2030. The example Summer event shown below features two hours with unserved energy (in red) starting at midday when SPP load is high. Four-hour DR (pink) performs at full capacity for four hours, including the period with unserved energy. A four-hour battery storage (purple) discharges at less than full capacity over seven hours. The Summer of 2030 exhibits critical hour periods which occur mostly but not entirely within four consecutive hours, resulting in four-hour DR ELCC of 83% at 2GW of adoption.

Figure 15: Example of Summer Loss of Load Conditions in RECAP with Four-hour DR



In the Winter, critical hours periods are longer resulting in lower DR ELCCs. The example Winter event shown below features ten-hour with unserved energy (in red) starting at 9am when SPP load is increasing and wind generation is low. Four-hour DR (pink) perform at full capacity for four hours, but the duration limit prevents it from performing over the entire period with unserved energy. Four-hour battery storage (purple) is similarly unable to perform at full capacity over the ten hours with unserved energy. The Winter of 2030 exhibits a large fraction of critical hour periods which are significantly longer than four consecutive hours, such as the event in this example, which results in four-hour DR ELCC of 36%.

Figure 16: Example of Winter Loss of Load Conditions in RECAP with Four-hour DR



DR ELCCs Decline with Incremental DR Penetration

ELCCs of certain resources experience saturation effects where ELCCs decline as the resource type becomes a larger fraction of the system's capacity supply mix. Figure 17 illustrates the declining ELCC phenomenon with increasing penetrations of energy limited resources (storage and DR). Increased penetrations of energy limited resources result in longer periods of critical hours, this in turn reduces the value of shorter-duration energy limited resources. The saturation of energy systems with energy limited resources is a consistent finding across multiple resource adequacy studies.[25, 26]

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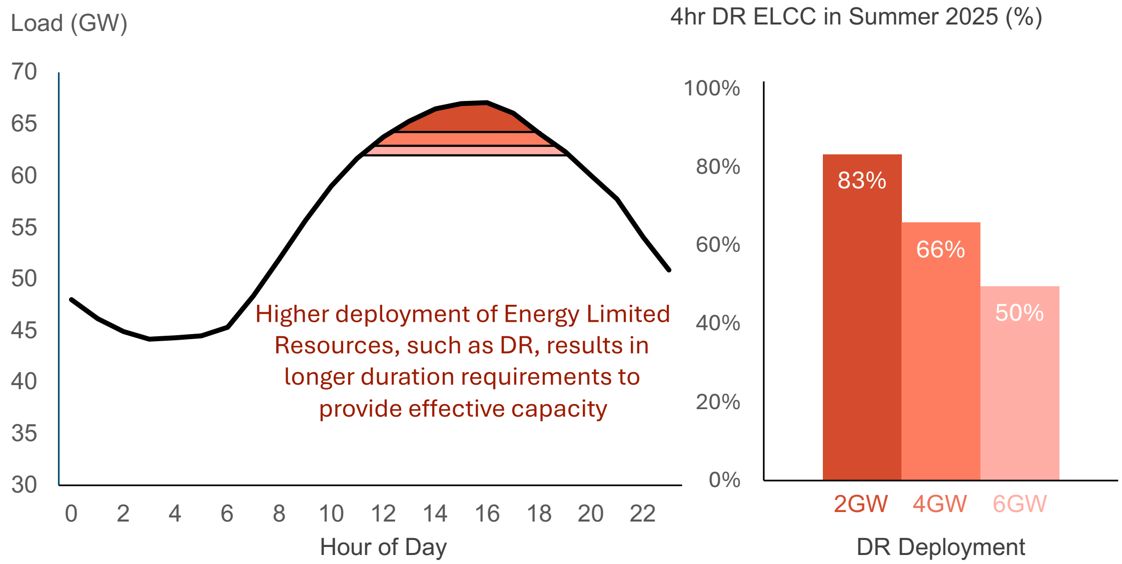
[25] Practical Application of Effective Load Carrying Capability in Resource Adequacy | E3

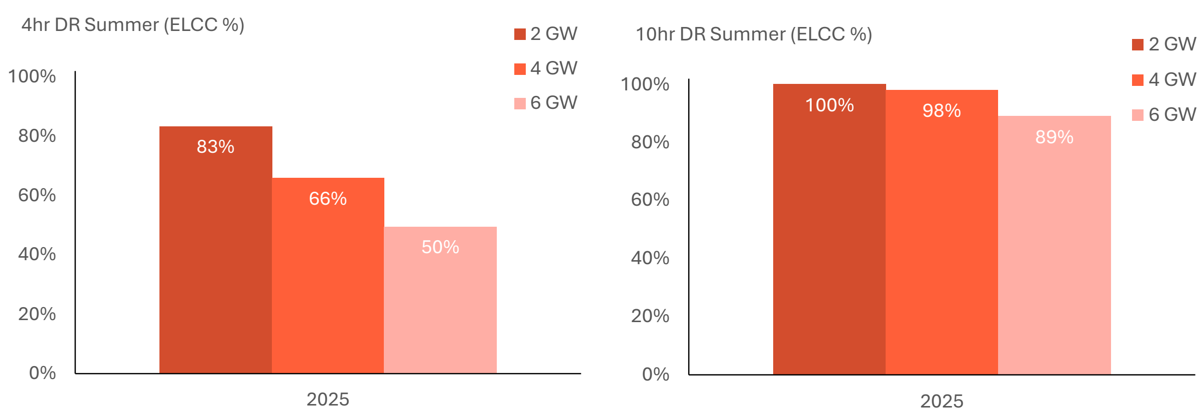
[26] A Critical Periods Reliability Framework and its Applications in Planning and Markets | E3

Figure 17: DR in SPP Exhibiting Saturation Effect of Energy-Limited Resources



To examine DR's sensitivity to higher penetrations, we tested additional scenarios with 4GW and 6GW adoption of DR in addition to the 2GW scenario. In 2025, four-hour DR starts at 83% ELCC but sees its value decline to 50% with 4GW incremental amounts of four-hour DR. For ten-hour DR, the saturation is less pronounced, but still present.

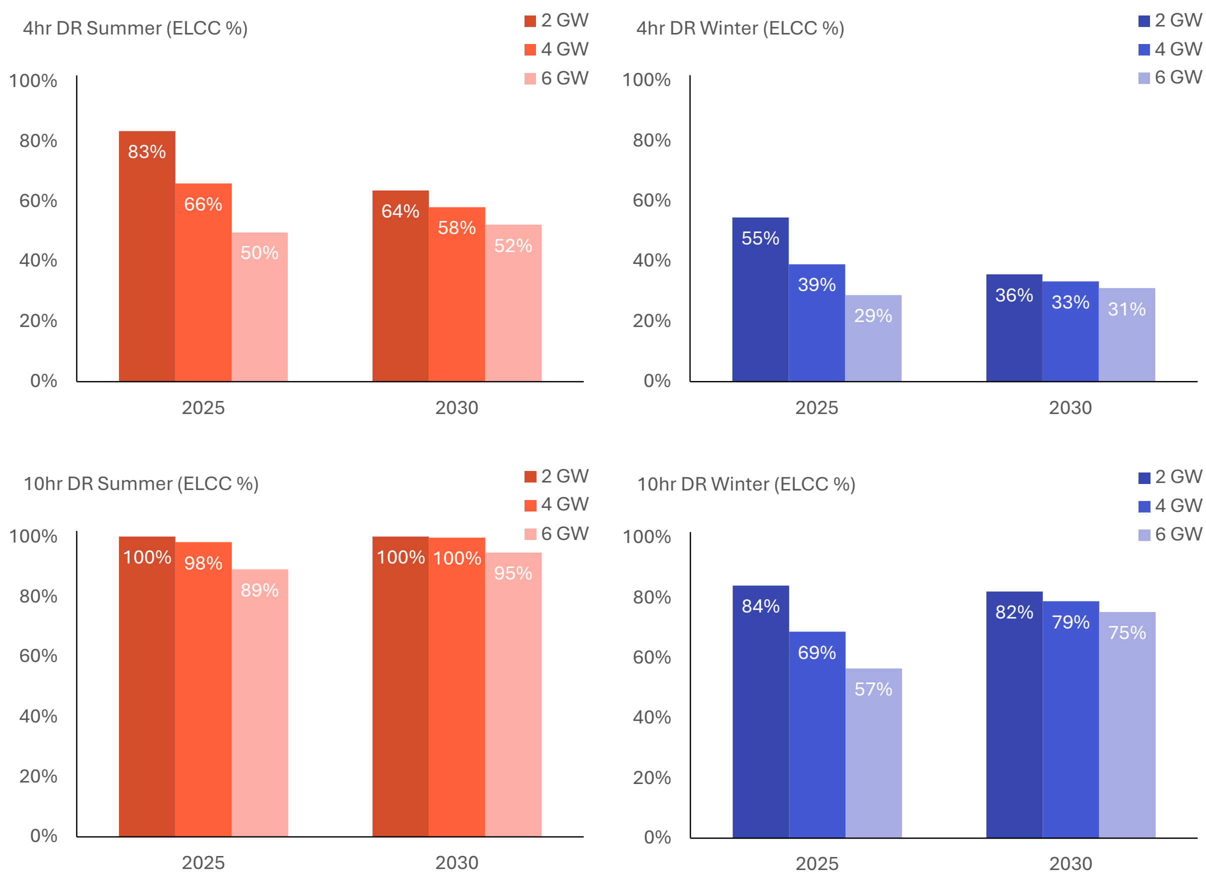
Figure 18: Four-hour and Ten-hour DR ELCCs by Adoption Level, Summer 2025



DR ELCCs in 2030: Effects on Capacity Accreditation as SPP Portfolio Mix Changes

By 2030, SPP's portfolio shifts significantly, with most incremental capacity additions coming from thermal, wind, solar, and storage resources. From 2025-2030, SPP portfolio undergoes several changes including 13GW of additional wind, 2GW of additional solar, and 5GW of additional four-hour battery storage. The rapid expansion of storage affects DR ELCCs by contributing to the saturation of energy limited resources on the SPP system, while rising wind and solar adoption provide diversity benefits that help support DR ELCCs over time. Diversity benefits between energy limited resources (DR and storage) with variable resources (solar and wind) is a phenomenon consistently observed across resource adequacy studies.[27,28] The net impact of changes in the SPP system from 2025-2030 is a decrease in four-hour and ten-hour DR Summer ELCCs, whereas the impact on Winter ELCCs is more complex and described further in this section.

Figure 19: DR ELCCs by Year and Market Adoption Level



Compared to 2025, four-hour DR ELCC declines by 2030 in both SPP's Summer and Winter seasons at 2GW and 4GW of adoption. In 2030, DR ELCCs benefit from the diversity benefit of additional variable resources (solar and wind) coming online. However, the 5GW of additional energy limited resources (four-hour battery storage) by 2030 contributes to the saturation of energy limited resources in SPP.

Notably, four-hour DR ELCCs at 6GW adoption is stable between 2025 and 2030. This indicates the diminishment of the saturation effect, which occurs when the duration of reliability events stabilizes

[27] Practical Application of Effective Load Carrying Capability in Resource Adequacy | E3
[28] A Critical Periods Reliability Framework and its Applications in Planning and Markets | E3

despite additional increments of energy limited resources. As seen in these results, the saturation stabilization effect typically happens at relatively low ELCC levels.

In contrast to four-hour DR, ten-hour DR sees a slight increase in ELCC between 2025 and 2030. Unlike four-hour DR which is on the same saturation curve as four-hour battery storage, ten-hour DR is less impacted by the four-hour battery storage resource since it has additional performance capabilities. Under optimal dispatch, the ten-hour and four-hour resource can be dispatched strategically to minimize or prevent loss of load in a manner which is not possible when only a single duration of energy limited resource is available to the system. The slight increase of ELCCs for ten-hour DR indicates that the diversity benefit from more renewables in 2030 outweighs the saturation effect of additional energy limited resources on the system.

However, if longer duration battery storage were to enter the system, ten-hour DR would see ELCCs lower than presented in this study. Since resources receive new ELCC accreditation values annually, based on system conditions in the forthcoming delivery period, the sensitivity of ELCCs to market portfolio changes is a key consideration. These results highlight how energy limited resources interact with one another, and how longer duration resources can benefit from ELCCs which decline more slowly over time.

Other Market Impacts on DR Operations and ELCC

While not comprehensively explored in this study, changes in the resource mix, especially renewables and storage resources, also affect DR's reliability contributions. ELCCs are shaped by saturation and diversity effects. Solar saturation occurs when additional solar provides diminishing incremental capacity value, since critical evening hours increasingly fall after sunset. Storage saturation similarly arises when large quantities of short-duration storage flatten net load curves, requiring subsequent tranches to cover longer and less frequent events. However, when ELRs like storage are paired with variable renewables, they generate meaningful diversity benefits: storage can shift surplus solar into evening peaks, while solar reduces the depth and duration of storage dispatch needed.

Table 5: Impact of Market Conditions on DR Capacity Value

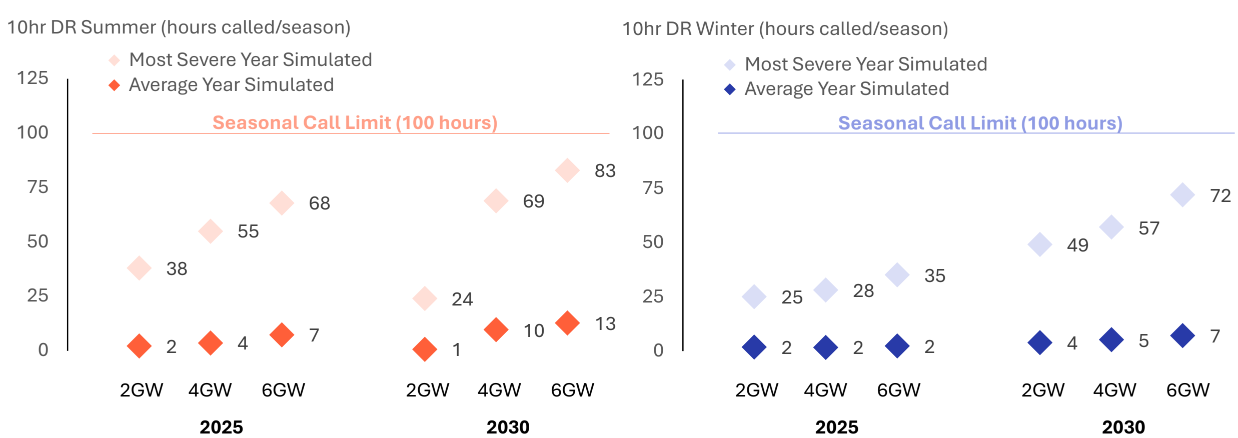
Scenario	Impact on DR ELCCs	Impact on DR Calls
Accelerated renewable adoption	Increase *Due to diversity benefit*	Increase/Minimal Change *Depends on portfolio sufficiency*
Accelerated DR adoption	Decrease *Due to ELR saturation*	Increase/Minimal Change *Depends on portfolio sufficiency*
Accelerated storage adoption	Decrease *Due to ELR saturation*	Minimal Change *Depends on portfolio sufficiency*
Accelerated load growth	Uncertain *Depends on load types*	Increase/Minimal Change *Depends on portfolio sufficiency*
Other resource mix changes	Uncertain *Depends on portfolio composition*	Uncertain *Depends on portfolio composition*

DR Duration is more important than its Seasonal Call Limit

Across the DR durations (four-hour, ten-hour), adoption levels (2GW, 4GW, 6GW) and test years (2025, 2030) examined for SPP, removing the seasonal call limit only impacts DR ELCCs in the Summer 2030 scenario with 6GW of ten-hour DR, this result is discussed further below. For all other scenarios, DR calls are not reaching the seasonal call limit, hence removing the seasonal call limit does not change DR ELCCs. In addition to calculating DR ELCCs for each scenario, we analyzed total hours DR is called by season. Since RECAP simulates each scenario over 960 simulated years, the average and highest number of hours DR is called by season could be extracted. The figure below shows the average (average year simulated) and highest (most severe year simulated) number of hours ten-hour DR is called per season, when seasonal call limits are imposed.

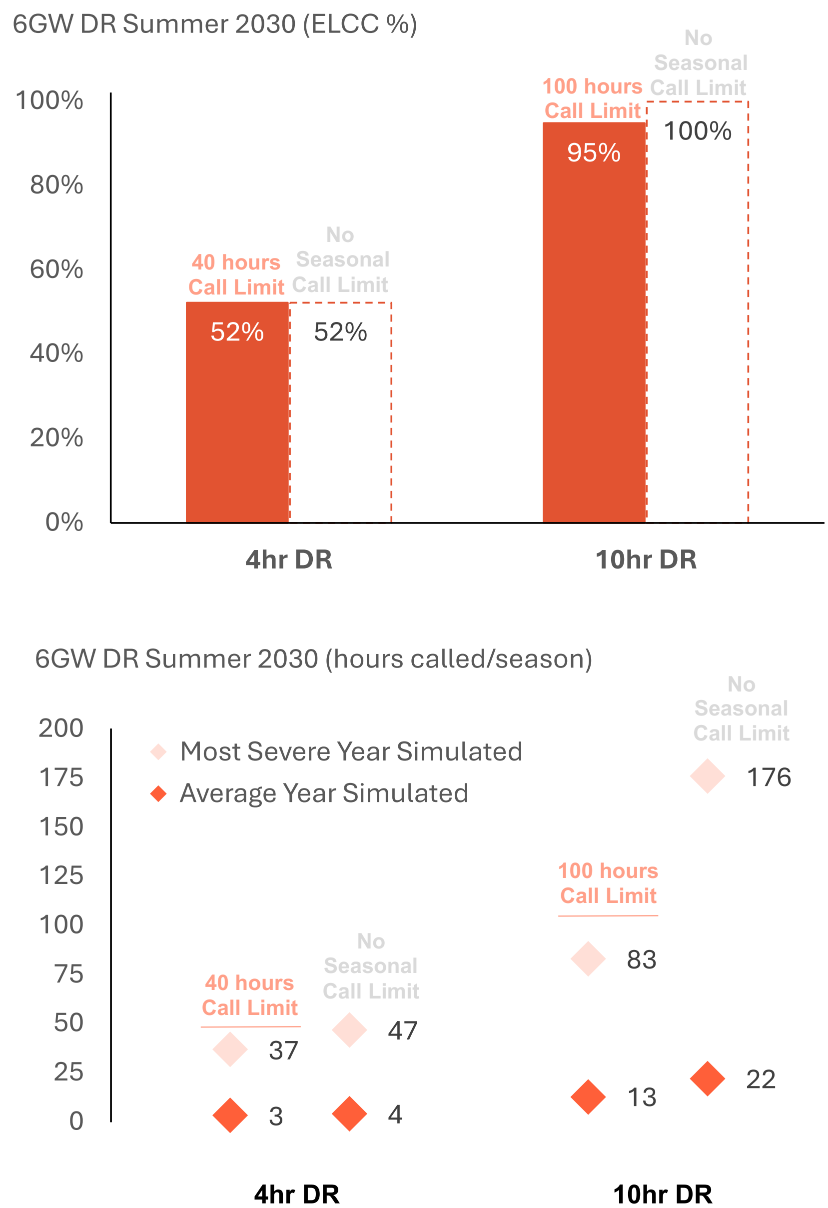
In Summer 2025-2030, ten-hour DR is called for 1 to 13 hours over the entire season of the average simulated weather year. In Winter 2025-2030, ten-hour DR is called for 2 to 7 hours over the entire season of the average simulated year. Over the entire year, ten-hour DR is called for 3 to 20 hours, significantly less than the seasonal call limit of 100 hours. Over the 960 simulations of each scenario, total DR calls reach 83 hours in the most severe Summer simulated and 73 hours in the most severe Winter simulated, both at 6GW of ten-hour DR adoption in 2030. In the average year, DR is called far less than the seasonal call limit, however, achieving the DR ELCCs presented in the above sections requires the capability of DR to be utilized up to its specified seasonal call limit.

Figure 20: Ten-hour DR Utilization by Year and Adoption Level



The seasonal call limit does impact DR ELCCs in SPP under certain system conditions, involving the high DR penetration levels. The Summer of 2030 with 6GW of ten-hour DR is the only scenario tested where removing the seasonal call limit increases ELCCs. In 2030, ten-hour DR receives a 100% ELCC when it does not have a seasonal call limit and is used for 176 hours in the most severe weather year. In contrast, ten-hour DR with the seasonal call limit receives 95% ELCC.

Figure 21: DR ELCCs in Summer 2030 by Duration and Call Limit, 6GW Adoption



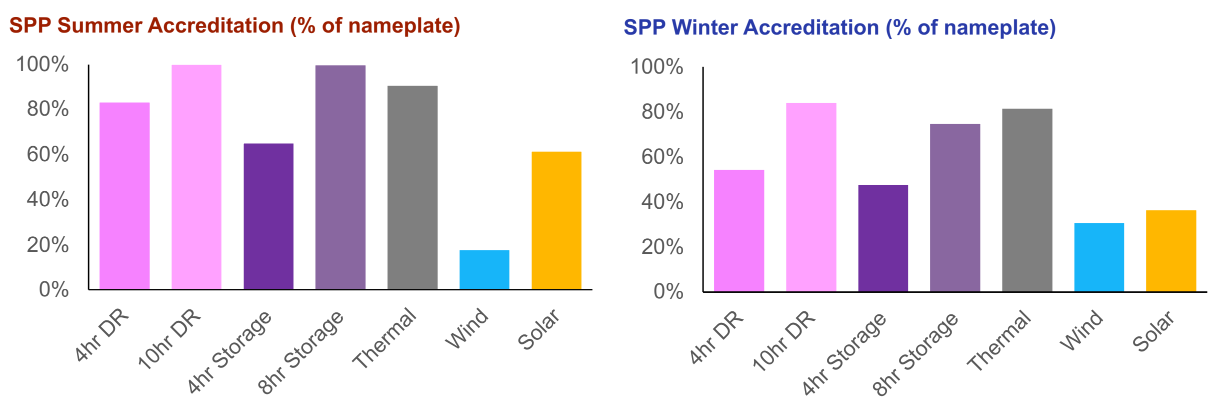
Meeting SPP's Near- and Long-Term Reliability Needs

This section seeks to explore the viability of DR as a capacity resource within the SPP market. We compare DR ELCCs to other resources in SPP to understand how DR could add to the resource adequacy market in SPP. Further, we explore the impact DR could make in the short term if load growth outpaces supply additions in the SPP footprint due to procurement and interconnection bottlenecks for supply-side resources.

DR vs. Accredited Supply Side Resources

To understand DR's potential role in SPP's resource mix, we take the ELCC results from the previous section and compare them to accreditation values of supply-side resources from SPP's most recent studies. [29] The figure below shows that for today's system, four-hour DR has ELCC values comparable to four-hour battery storage ELCCs in both Summer and Winter. Ten-hour DR has ELCC values comparable to 8hr battery storage ELCCs and thermal ACAP values in both Summer and Winter. The DR ELCCs shown are associated with the lower seasonal call limit (40 hours/season for four-hour DR & 100 hours/season for ten-hour DR) at 2GW of market adoption. As discussed in the Results section, the duration (measured as maximum daily availability) is the key performance characteristic determining ELCCs for energy limited resources (both DR and battery storage) in SPP.

Figure 22: SPP Summer and Winter Capacity Accreditation by Resource



While SPP has not performed ELCC studies out to 2030 yet, based on the results for DR, we anticipate that wind, solar, and battery storage will also face saturation headwinds, as we anticipate that wind, solar, and storage provide the most growth in the near-term based on late-stage

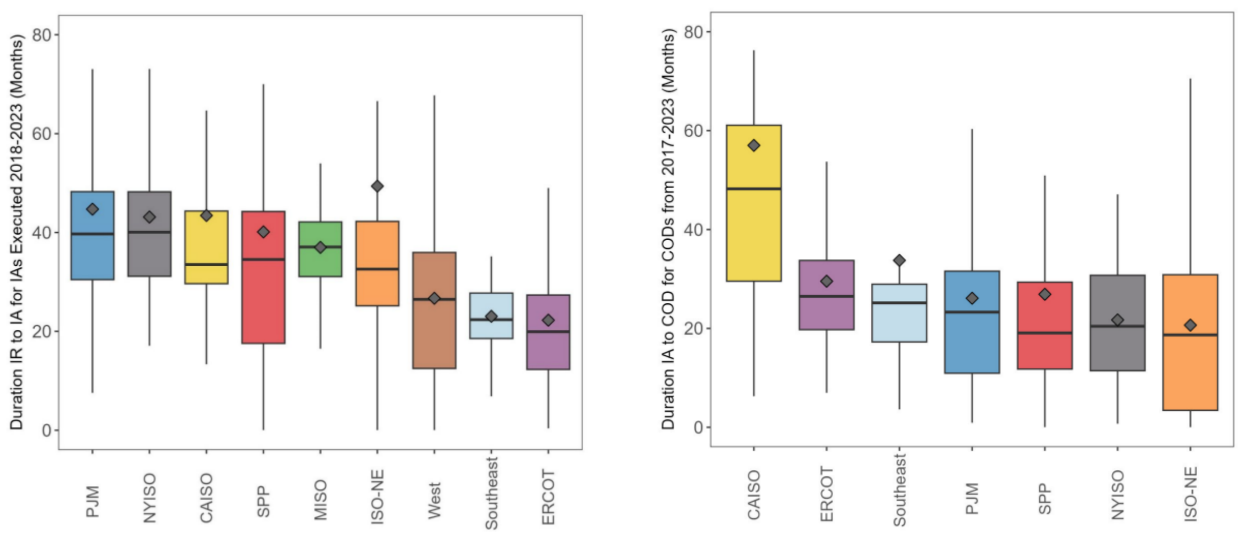
[29] DR accreditations are E3's 2025 RECAP ELCC results (2GW adoption, 40hrs/yr for 4hr DR, 100hrs/yr for ten-hour DR). Storage, Wind, and Solar accreditations are Tier 1 ELCCs from SPP's 2024 ELCC study. Thermal accreditation is conventional fleet average ACAP from SPP's 2025 ACAP informational posting.
The comparisons of accreditation across multiple data sources are not exactly "apples to apples" due to differences in study timing, given Seasonal changes in SPP resource mix, loads, and accreditation methodologies. SPP's ELCC and ACAP values are published Seasonal, with the 2025 ELCC study expected in late 2025.

interconnection projects. As such, we anticipate that the 2025 relative ranking to hold similar for 2030.

RA Risks and Opportunities in SPP

One potential benefit to the integration of DR from large loads looking to enter SPP is the speed at which DR can deploy. As Lawrence Berkeley National Laboratory demonstrates in their 2024 *Queued Up* report, SPP is facing an average of 40 months from the interconnection request coming in to signing interconnection agreements. SPP then sees an average of 30 months from interconnection agreement signature to interconnection commercial operations. That is a total of ~70 months or almost six years. This also does not consider pre-interconnection application development activities.

Figure 23: Total Interconnection Timelines for SPP Generation



Source: LBNL Queued Up: 2024 Edition - Energy Markets & Policy

Similarly, industry is facing delays on items like gas turbines. Recently, large developers like NextEra have announced on earnings calls that they are facing challenges getting new turbines installed by 2030.[30] This problem is systemic across industry. As developers have increased orders in response to demand growth, alongside demand from other non-power sector turbine customers, turbine manufacturers have reached production capacity.[31, 32] Even if interconnection speeds are accelerated for reliability purposes,[33] supply chain constraints will be binding unless the project is already under construction or has its major equipment secured.

As SPP sees increased near-term load growth and as the HILL/CHILL processes develop, SPP LREs may find themselves in the scenario of needing new forms of capacity resources to manage growing

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30 Utility Dive - NextEra partners with GE Vernova to build 'gigawatts' of gas generation
31 Gas turbine manufacturers expand capacity, but order backlog could prove stubborn | Utility Dive
32 Texas' $7.2 billion loan program for gas power plants has approved two projects in two years | News From The States
33 PJM fast-tracks 11.8 GW, mainly gas, to bolster power supplies | Utility Dive

RA needs amidst supply-side constraints. DR from new large loads can achieve a high capacity accreditation and can be provided as soon as the load comes online.

Given the challenges SPP may face in a high load growth and constrained supply environment, DR should be considered a RA resource and used to provide valuable load reduction when the system needs it. Establishing clear and appropriate DR performance requirements, as explored in the rest of this paper, can facilitate fair and efficient adoption of DR in the SPP market. This will help SPP LREs manage difficult supply-demand balances as the market adopts large loads and continues to decarbonize.

Conclusion

This paper demonstrates that Demand Response (DR) is a valuable capacity resource in SPP, even when subject to a seasonal call limit. Our loss-of-load probability modeling of SPP in 2025-2030 showed that DR with duration and seasonal call limits has significant resource adequacy value in SPP's critical hours. Four-hour DR with a 40 hour/season call limit provides significant system value in both Summer and Winter, measured in ELCC. Longer-duration DR resources provide even greater effectiveness in both seasons, with especially pronounced benefits in Winter, when cold snaps create multi-hour or multi-day reliability challenges that shorter-duration resources cannot fully address. These findings highlight the importance of duration as a key driver of DR's ELCC.

Importantly, DR remains effective even with seasonal call limits, based on hundreds of simulations across diverse weather years and portfolio conditions. In most years, the system requires far fewer calls (often fewer than five) to address the highest-risk events. DR with no seasonal call limits was shown to have slightly higher ELCC than DR with seasonal call limits, but only in 1 of the 8 scenarios tested. This suggests that DR providers do not need to commit to unlimited dispatch to achieve high accredited capacity in SPP. Instead, carefully designed programs that balance duration, call frequency, and availability can result in DR providing dependable capacity at low system cost.

An efficient and scalable DR market design should have resource class performance characteristics which are clearly designed, supportive of SPP resource adequacy needs, and mitigate risks to DR providers. DR utilization in the average and most severe simulated weather year analyzed in this study provide guidance on the appropriate seasonal call limits that DR programs should consider.

As SPP continues to refine its accreditation and resource adequacy frameworks, integrating DR as a resource with performance-based accreditation will be essential. Recognizing DR's capacity accreditation alongside storage and other energy-limited resources ensures fair crediting and enables LREs to deploy DR as a cost-effective hedge against near-term uncertainty. In this role, DR can provide a critical bridge resource, reducing the risk of loss-of-load events while the region advances new generation and transmission development needed for long-term reliability and decarbonization.