The Evolution of Resource Accreditation

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The authors are solely responsible for any omissions or errors contained herein.

Webinar Series Overview

1) Overview of Webinar Series and Connections to State Planning Efforts
    - October 14, 2:30-3:30 p.m. Eastern
    - Juliet Homer & Eran Schweitzer (PNNL)
2) Developing Forecasts - General Overview
    - October 23, 4-5 p.m. Eastern
    - Brittany Tarufelli & Allison Campbell (PNNL) and J.P. Carvallo (LBNL)
3) Developing Forecasts – Load Expansion
    - October 29, 4-5 p.m. Eastern
    - Sean Murphy & J.P. Carvallo (LBNL) and Christine Holland (PNNL)
4) Developing Forecasts – Distributed Energy Resources
    - November 6, 2-3 p.m. Eastern
    - Sean Murphy & Margaret Pigman (LBNL) and Shibani Ghosh (NREL)

Webinar Series Overview

5) Resource Adequacy Analysis – Basics
   - **November 10, 3-4 p.m. Eastern**
   - Jose Lara, Sebastian Machado, & Rafael Monge (NREL) and Allison Campbell & Eran Schweitzer (PNNL)

6) Transmission and Distribution System Planning – Basics
   - **November 13, 3-4 p.m. Eastern**
   - Jose Lara & Vincent Westfallen (NREL)

7) The Evolution of Resource Accreditation
   - **December 2, 3-4 p.m. Eastern**
   - Travis Douville (PNNL)

Content Agenda

- Context and definition
- Key principles
- Conventional planning
- Key changes to the electricity sector
- Deterministic and probabilistic
- Prospective and retrospective
- Marginal and average
- Summary
- Q&A

Andrea Starr | Pacific Northwest National Laboratory

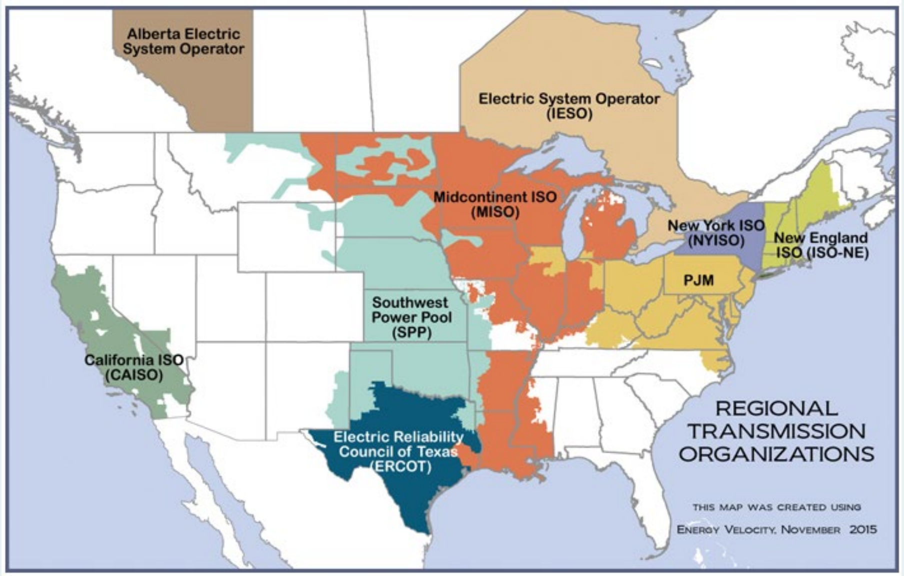
Reliability frameworks in central planning and competitive markets

Regulated wholesale markets

Vertically-integrated utilities in West & South

Capacity value:

1. Justifies procurement decisions
2. Informs bilateral contracts
3. Provides reference for avoided costs of demand-side resources



FERC (2020)

*AESO & ERCOT operate without forward capacity markets and instead incentivize capacity through spot energy and ancillary services markets.

Restructured wholesale markets

*Competitive power markets through RTOs/ISOs**

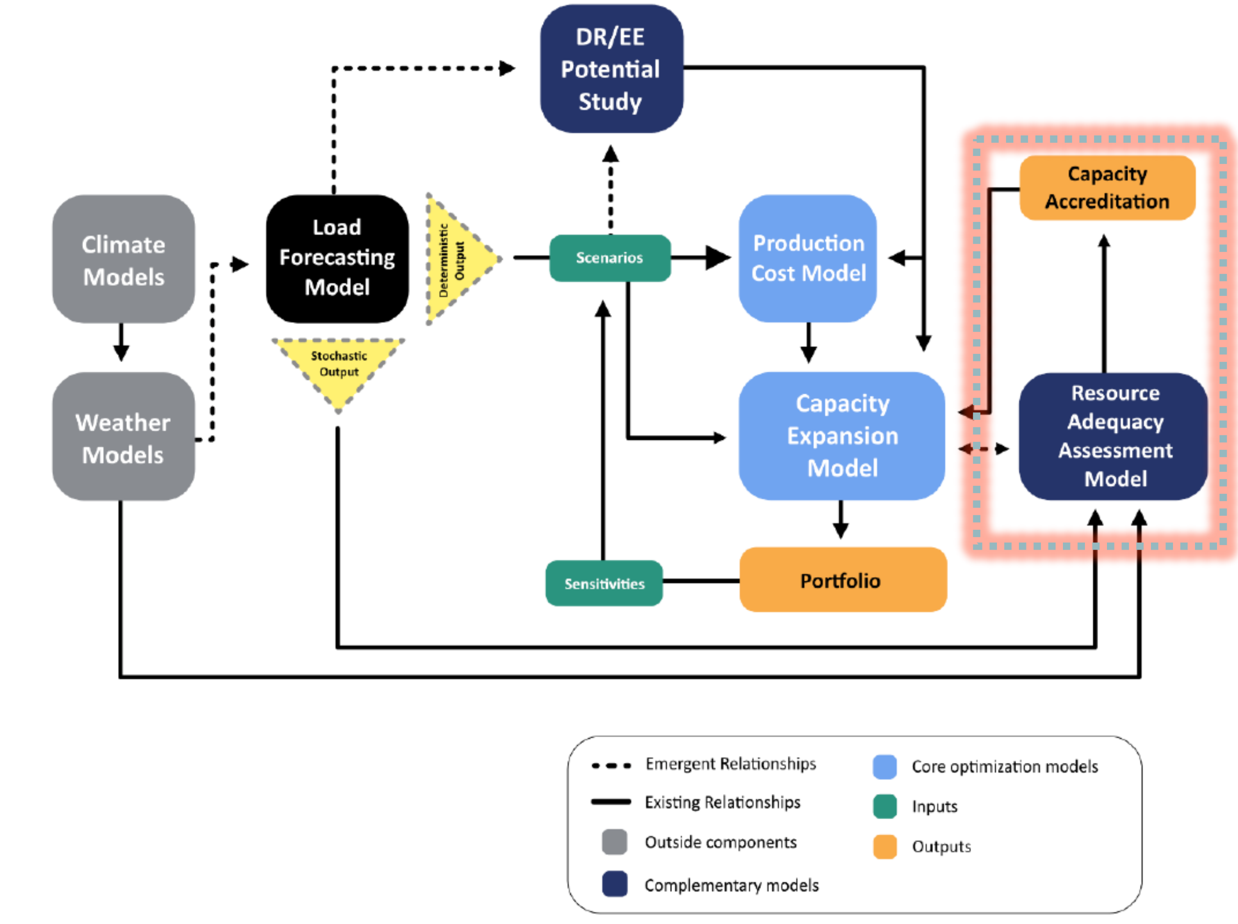
Capacity value:

1. Provides efficient investment signals
2. Allows market participants to support long-term reliability
3. Supports complementary planning

Resource Accreditation Within Resource Planning Processes

- Resources are planned for multiple objectives: affordability, reliability, public policy.
- Resource adequacy is a subcomponent of resource planning that verifies long-term reliability of a resource mix.
- Resource accreditation[1] informs capacity expansion optimization.

1. **Resource accreditation** in this context refers to a formal acknowledgement of resource capacity contribution by a system planner or market operator.



Note: DR refers to demand response. EE refers to energy efficiency.

Synapse & LBNL (2024)

Key Principles of Resource Accreditation

ESIG's Redefining Resource Adequacy Task Force developed five pillars:

Non-Discriminatory	Robust	Transparent	Reliable	Predictable
Accreditation is applied to all resources using a similar methodology.	Accreditation continues to work as the resource mix, load patterns, and system risk change over time.	Accreditation can be effectively communicated to stakeholders, and data are readily available for decisionmaking.	Accrediation accurately measures performance during real scarcity events.	The process is repeatable and consistent. It does not yield volatile or unexplained changes year to year.

ESIG (2023)

Capacity valuation in conventional planning

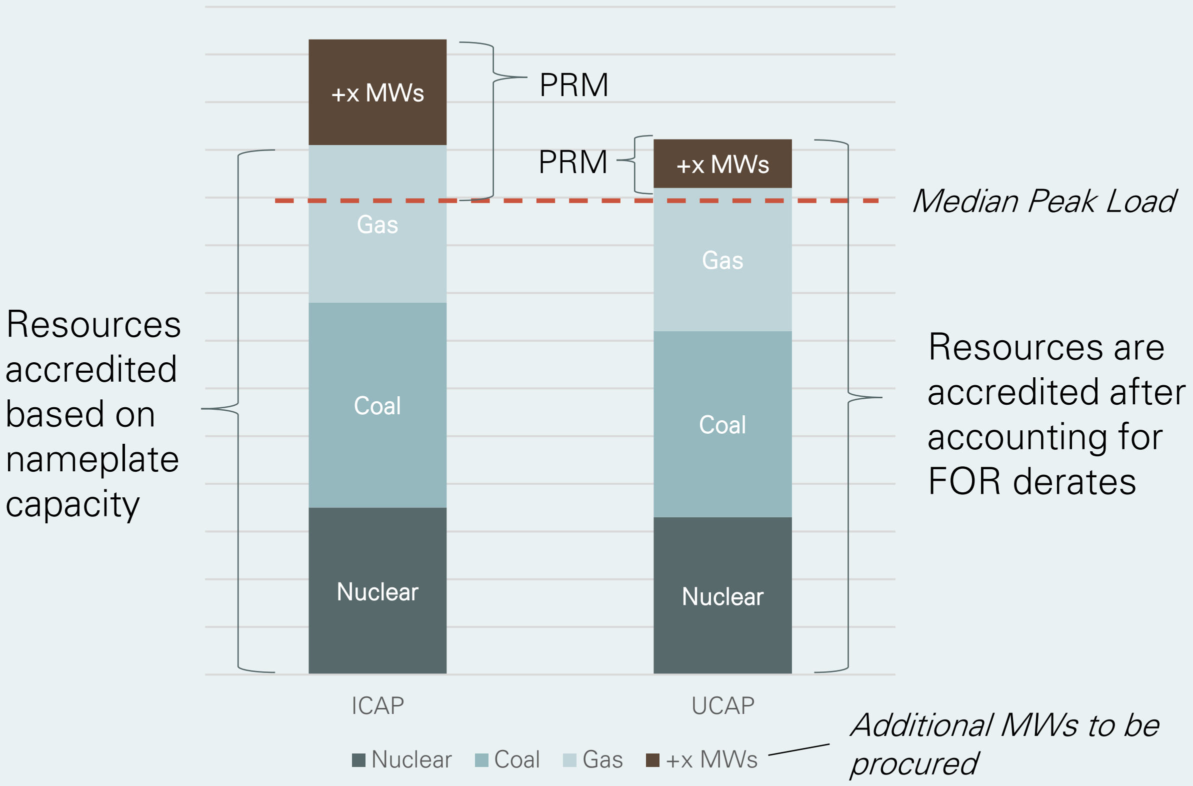
Installed Capacity Method (ICAP)

- Installed Capacity is simply a summation of generator nameplate ratings
- Planning Reserve Margins (PRMs) are used to build enough capacity to meet peak load uncertainty and support operating reserves, including generator forced outage rates (FORs), while meeting RA criterion (e.g., 0.1 event days per year)

Unforced Capacity Method (UCAP)

- Same as ICAP but de-rates nameplate capacity of each generator by its expected FOR
- Lowers the system PRM by incorporating FOR into the generator capacity directly

PRMs (typically 10-15% ICAP) are outputs from RA and inputs to the capacity expansion process, which then matches them to least-cost resources



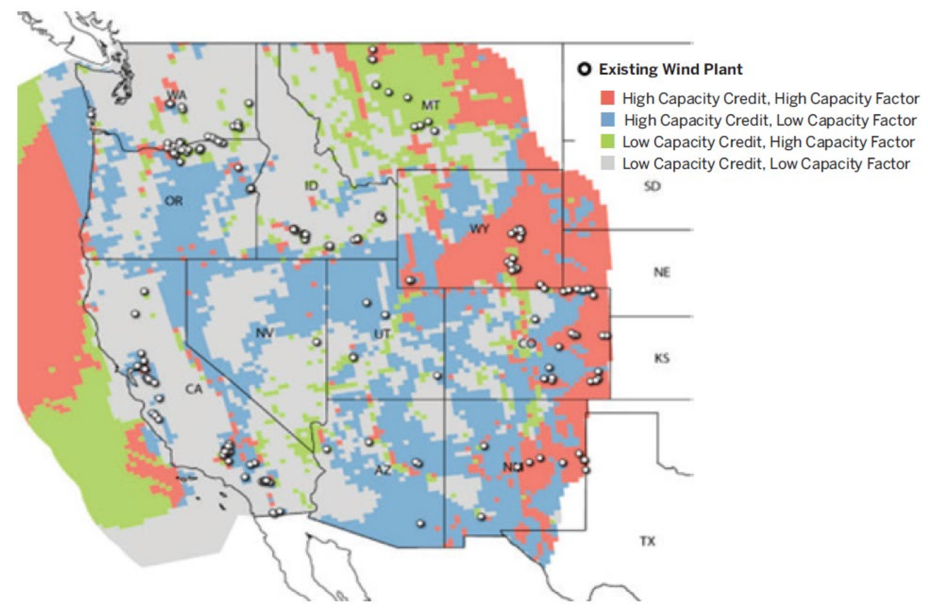
Factors challenging conventional approach

ICAP/UCAP-based planning assumes:

1. Capacity during peak load is most important
2. There are only small differences in resource performance during these times
3. Resources perform independently

But there are (4) critical shifts in the power system:

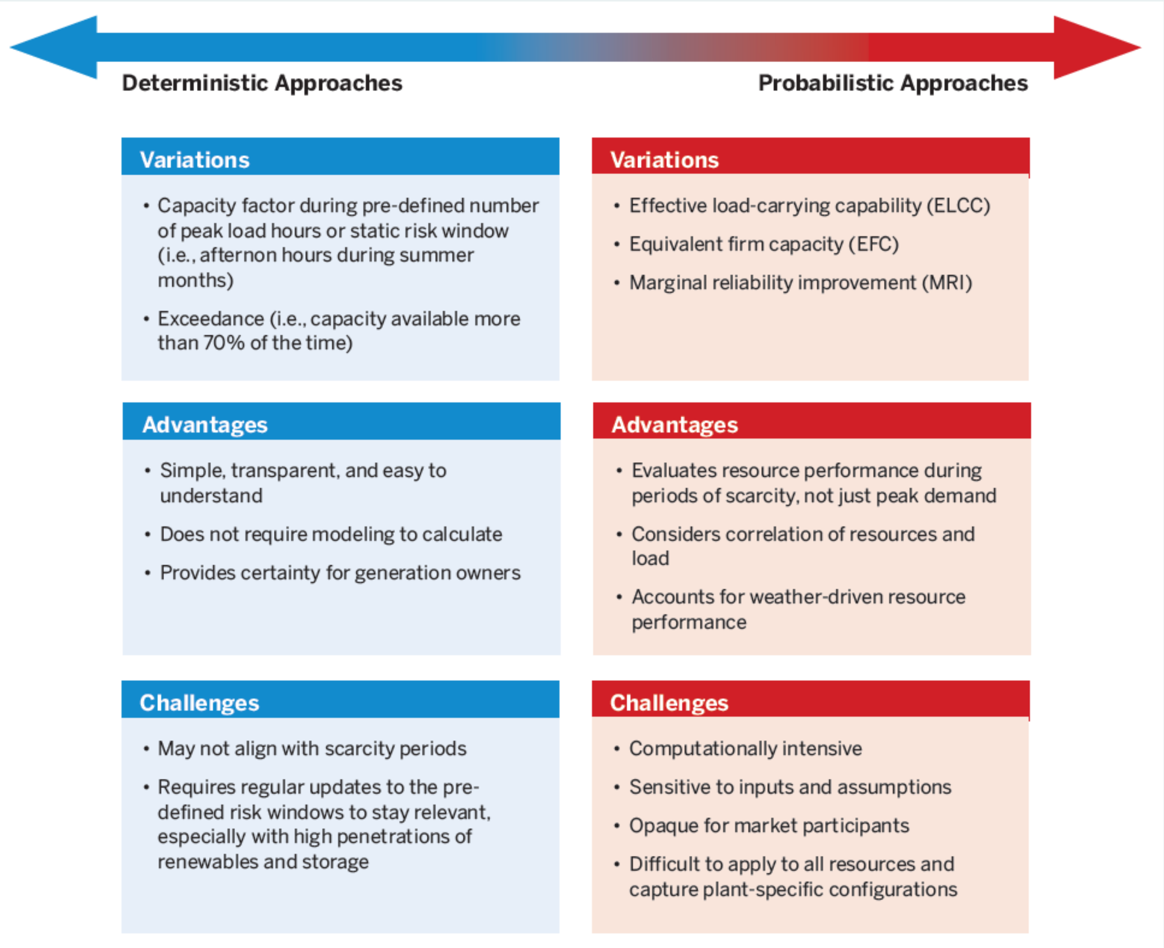
1. Capacity shortfall concerns present off peak
2. There are large differences in resource performance during these off-peak conditions
3. Resource performance is more inter-dependent (linear summations are inappropriate).



Jorgensen et al. (2021)
Olsen et al. (2025a)

For these reasons, *portfolios* of resources must be considered for their capacity contributions during evolving risk times rather than summing individual units at peak.

Deterministic vs. Probabilistic Approaches

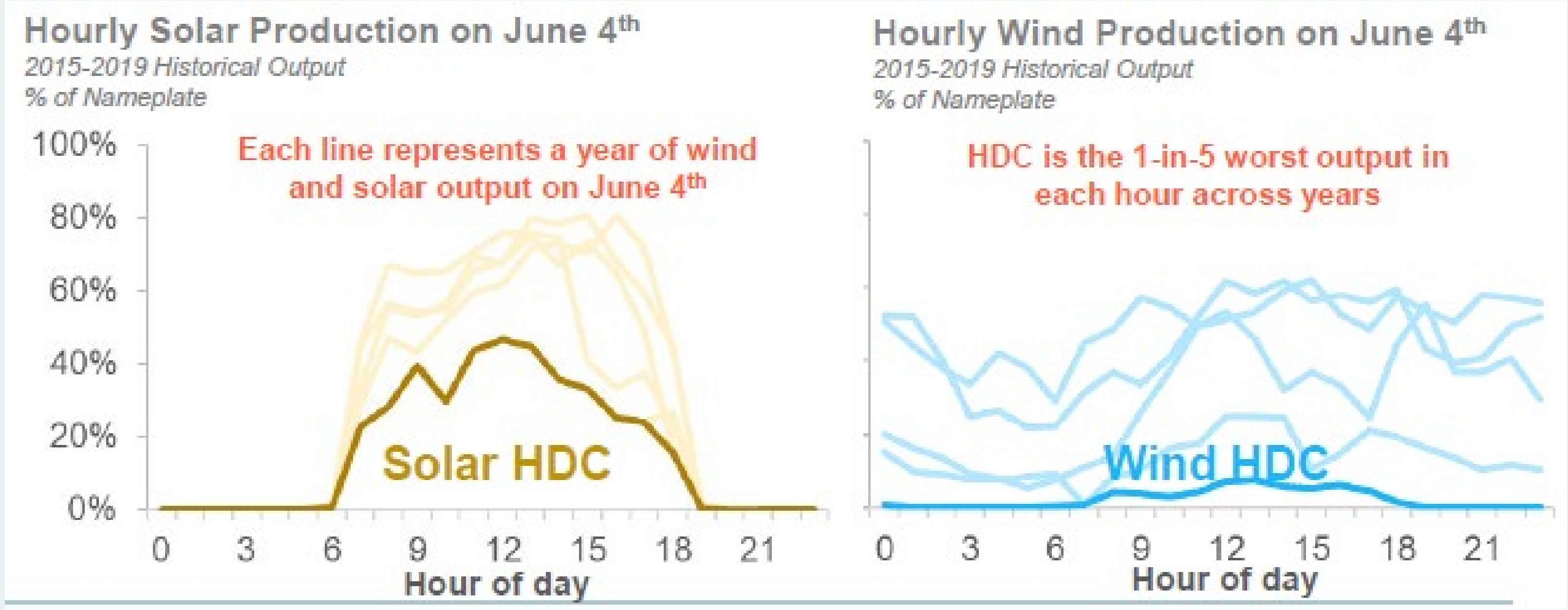


ESIG (2023)

- Deterministic models are **transparent** and easy to understand. However, they may **predetermine hours of risk**, or they may be **limited to a short historical record**.
- Probabilistic models will **catch changing timing of risk periods** and their causes. However, they are **more complex, opaque, and implementation requires more time and expertise**.

A deterministic approach—Hawaii Electric

- **Hourly Dependable Capacity** is calculated as an 80% probability of exceedance by hour from years 2015-2019 (i.e., the lowest capacity factor in an hour over 5 years).
- This is combined with an energy reserve margin to meet 0.1 days per year LOLE
- Hawaii Electric also considers coincident performance in **Hourly Expected Capacity**.

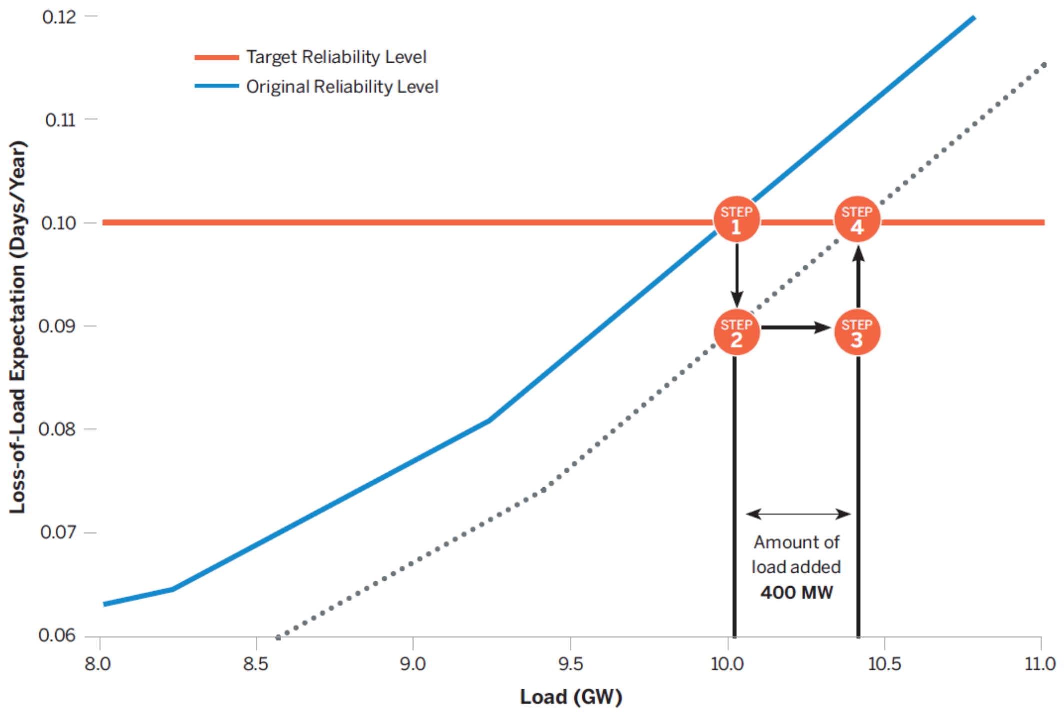


Olson et al. (2023)

Effective Load Carrying Capability (ELCC)

- A common *probabilistic* metric.
- ELCC can be used to quantify the equivalent perfect capacity that a generation or transmission change can support.
- Portfolio valuation is supported by the method.
- Calculation can be computationally intensive and complex.

Illustration of the Four Steps in the ELCC Methodology



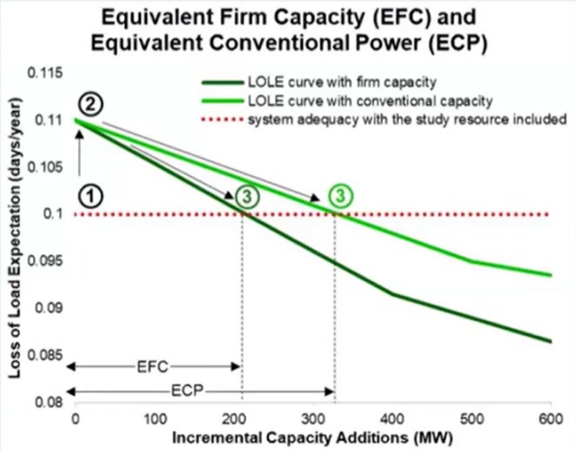
To calculate the ELCC of a resource, the system is first brought to the reliability criterion (e.g., 1-day-in-10-year LOLE) (step 1). In step 2, a resource is added to the system, thus reducing LOLE and making the system more reliable. The modeler then adds a fixed amount of load to the model in step 3 until the original LOLE criterion is reached (step 4). The difference between the amount of load added relative to the capacity added for a given resource is its ELCC.

ESIG (2023), Ibanez & Milligan (2014)

Alternatives to ELCC

- Equivalent Firm Capacity (EFC)
  - Like ELCC but equates to perfect capacity
- Equivalent Conventional Power (ECP)
  - Like EFC but considers power plant FOR, derates
- Estimated capacity credit (capacity factor during top net load hours)
  - Generation only, not compatible with portfolio value, does not require LOLP model
- Associated System Capacity Contribution (ASCC)
  - Simpler than ELCC, based on curtailment duration
- Direct Loss of Load (DLOL) method (MISO, 2024)
  - Mean capacity during critical hours
- Additional methods presented in Madaeni et al. (2012)

EFC, ECP



EPRI (2024)

Estimated capacity credit

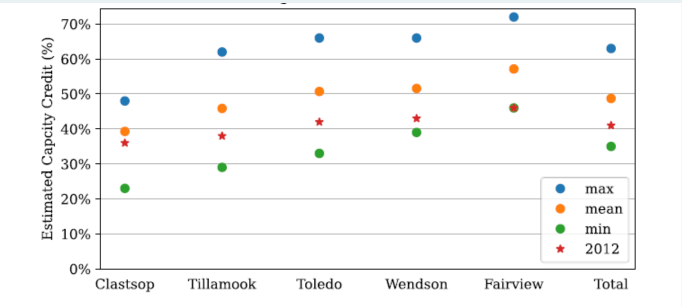
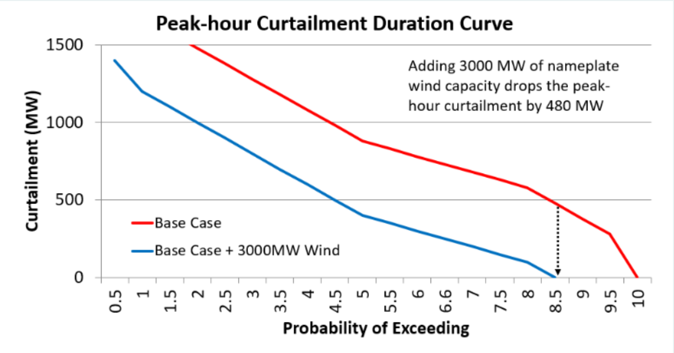


Figure 18. Distribution of estimated capacity credit for each site for the High Offshore, Future Grid scenario. Capacity credit is estimated by taking the average capacity factor of the offshore wind at each point of interconnection during the top 100 net load hours of the year for the Western Interconnection.

Novacheck & Schwartz (2021)

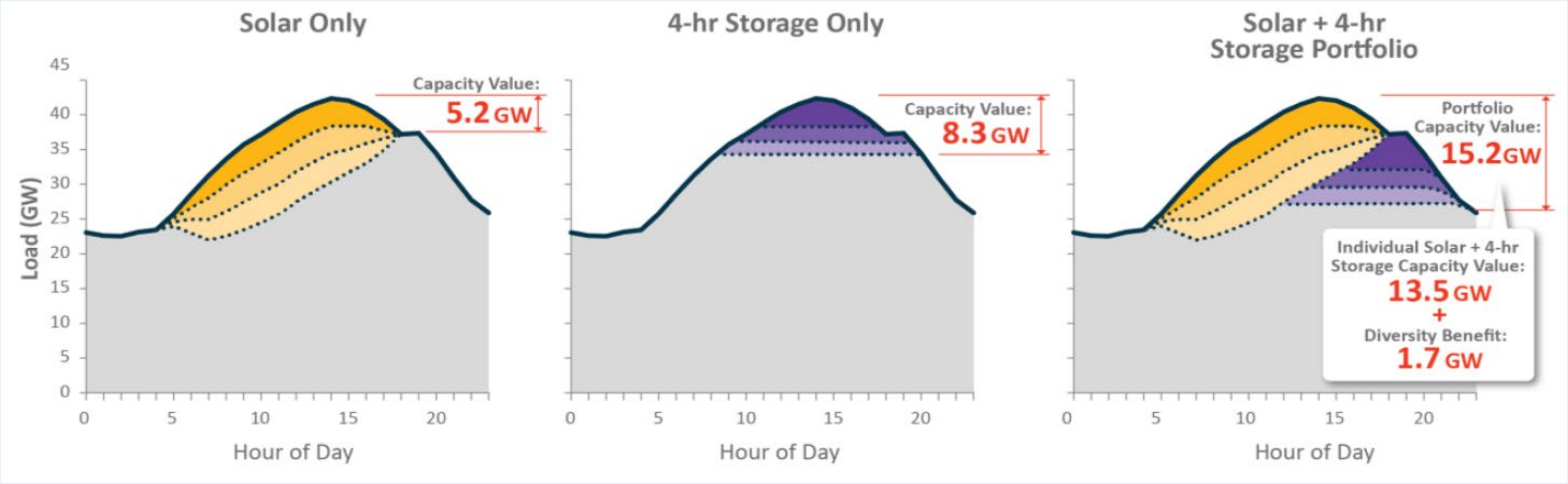
ASCC



NWPCC (2021)

Portfolio ELCC/Interactive Effects: Saturation, Diversity, and Resource Synergy

- Saturation: the more of a certain type of generator is added, the less capacity it provides to the system. Resource combinations can worsen saturation.
- Diversity: differences in time of generation, when correlated with demand, will improve portfolio capacity value.
- Resource synergy: some combinations extend capacity value of parts. These need to be modeled as a portfolio.

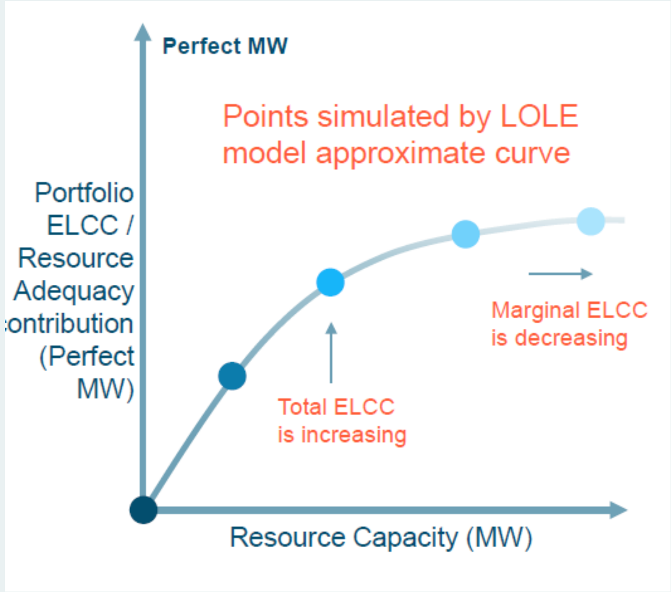


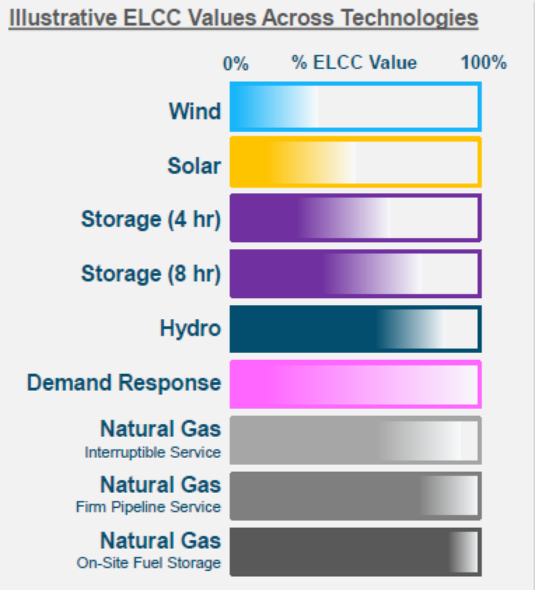
Schlag et al. (2020)

Marginal ELCC

- As a resource portfolio is shaped, the ELCC will change. Marginal ELCC (MELCC) projects what the next MW of capacity is worth (approximated as the first derivative of the ELCC curve).
- The portfolio ELCC is then the summation of the marginal values and any interactive effects.
- Resources will have varying MELCC

$$Portfolio\ ELCC = \sum_{i=1}^{n} MELCC_i + Interactive\ Effects$$



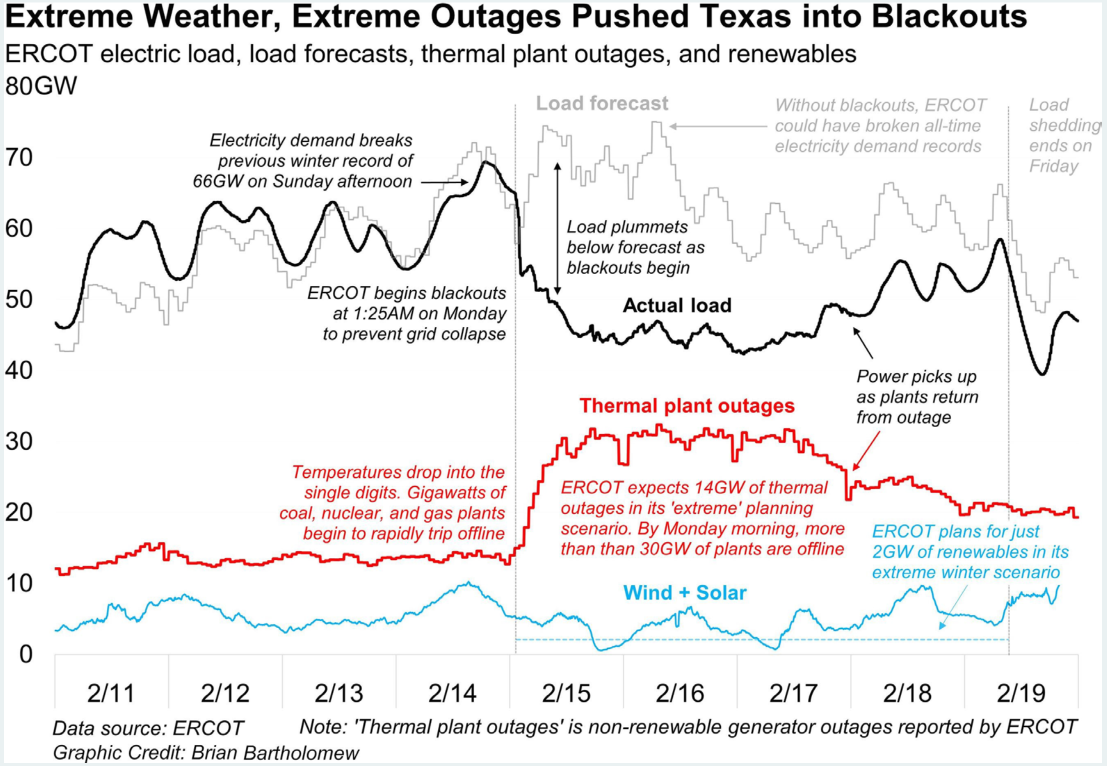


Olson et al. (2025)

Tail events

There are (4) critical shifts in the power system:

1. Capacity shortfall concerns present off peak
2. There are large difference in resource performance during these times
3. Resource performance is much more dependent (linear summations are inappropriate).
4. Widespread underperformance of conventional resources observed during major winter storms
    - Conventional accreditation (UCAP) of thermal generation is overly optimistic. Loss-of-load events are more likely to occur during periods of more thermal forced outages.
    - Best practice: Loss of Load Probability (LOLP) model, linking performance to weather.
    - Note: LOLP models will accredit thermal capacity lower than UCAP even if outages are random and uncorrelated.

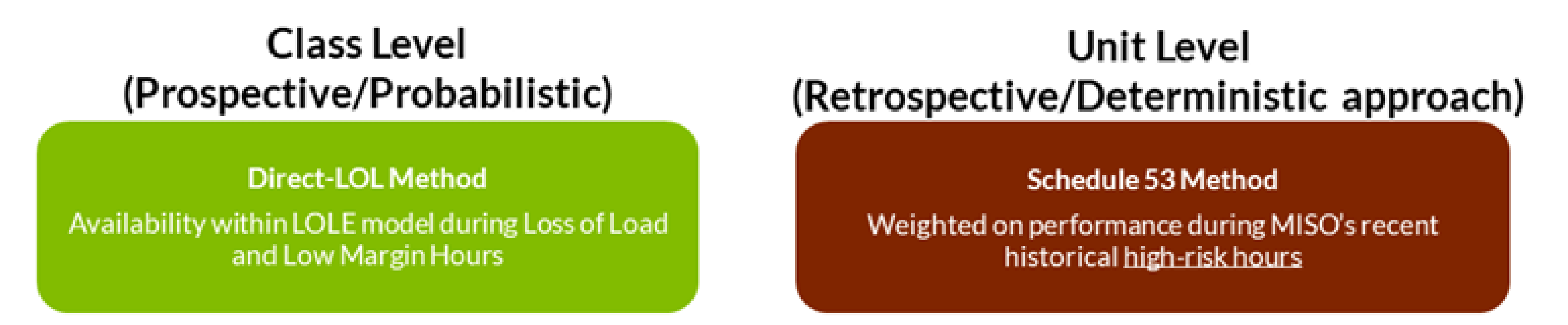


Correlated thermal outages have presented in recent winter storms, such as Uri (2021) and Elliott (2022)

Busby et al. (2021), Olsen et al. (2025a)

Prospective vs. Retrospective Approaches

- Prospective approaches rely upon simulations of grid and weather to estimate resource performance and system risk periods
  - Captures resource technology changes and new risk periods
- Retrospective approaches rely upon measured performance during observed risk periods.
  - Accounts for stacked uncertainties and risks not typically simulated
  - Creates an incentive for operational performance under tight margins
- Commonly, planners seek to leverage the best of both worlds, such as MISO:

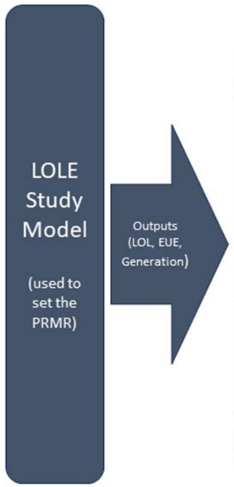


MISO. (2024)

MISO’s Prospective-Retrospective Accreditation

Class Level (Prospective/Probabilistic)	Unit Level (Retrospective/Deterministic approach)
Direct-LOL Method Availability within LOLE model during Loss of Load and Low Margin Hours	**Schedule 53 Method** Weighted on performance during MISO's recent historical high-risk hours

Resource classes first given a DLOL value based on LOLE model



System Unserved Energy

	Weather Year 1			Weather Year 2		
Hour of Year	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
1	0	0	0	10	0	0
2	0	0	0	0	0	0
3	0	0	0	0	0	0
4	20	0	0	0	0	0
5	40	0	0	0	30	0
6	10	0	0	0	10	0
7	0	0	0	0	5	0
8	0	0	0	0	2	0
9	0	0	0	0	1	0
10	0	0	0	0	0	0
....	0	0	0	0	0	0
8757	0	0	6	0	0	0
8758	0	0	10	0	0	0
8759	0	0	2	0	0	0
8760	0	0	0	0	0	0

Generator Availability
(installed capacity = 10 MW)

	Weather Year 1			Weather Year 2		
Hour of Year	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	1	1	1	0	0	0
4	4	4	4	2	2	2
5	8	8	8	3	3	3
6	3	3	3	1	1	1
7	1	1	1	0	0	0
8	0	0	0	0	0	0
9	0	0	0	0	0	0
10	1	1	1	2	2	2
....	0	0	0	0	0	0
8757	5	5	5	6	6	6
8758	10	10	10	0	0	0
8759	6	6	6	6	6	6
8760	3	3	3	1	1	1

Two weather years, 6 outage samples per weather year, 2 days with LOL per weather year
LOLE = # days/# samples = 2 days/3 samples = 0.67 days/year
LOLH = # hours/# samples = 6 hours/3 samples = 2 hours/year
EUE = # unserved MWh/# samples = 146 MW / 6 samples = 24.3 MWh/year

Average output during events: 3.33 MW
Nameplate Capacity: 10 MW
Capacity Accreditation: 33%

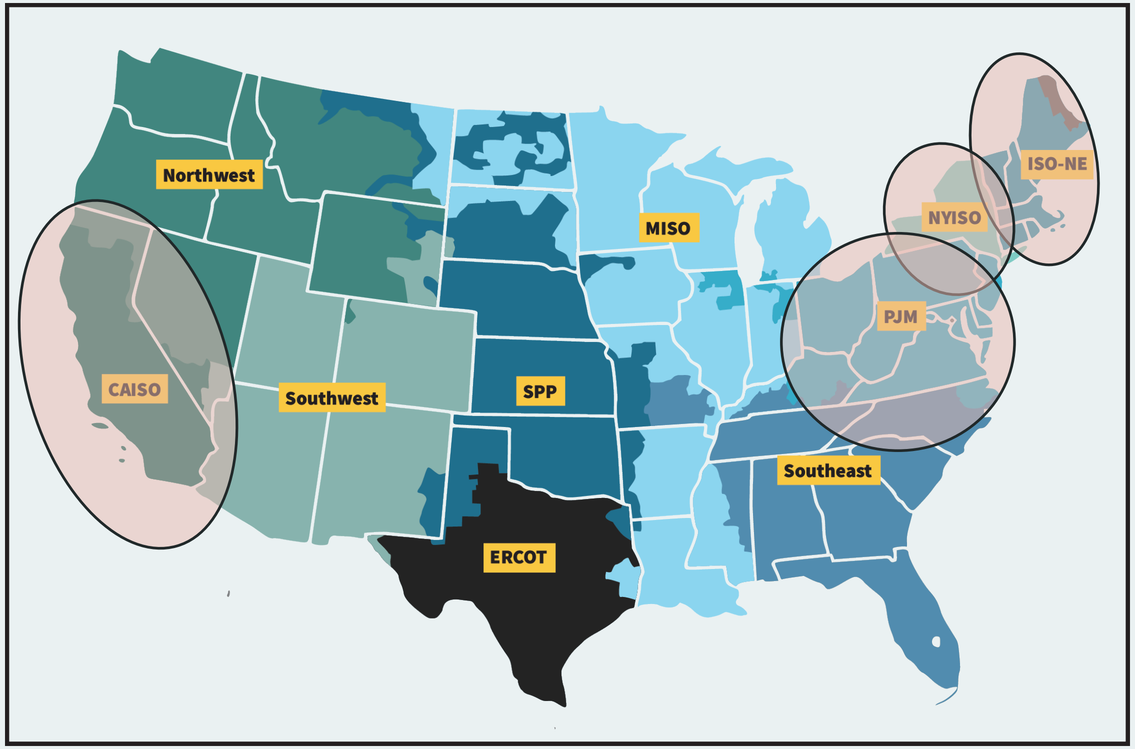
Resource class value then allocated to individual resources based on operational performance

Resource	ICAP	Tier 1 Hour Availability	Tier 2 Hour Availability	Intermediate SAC (ISAC)	Final SAC	% Credit (SAC/ICAP)
Resource class-level UCAP megawatt determined by the DLOL method from LOLE analysis = 50 MW						
Unit 1	5	2	3	2.8	2.6	52%
Unit 2	10	7	8	7.8	7.3	73%
Unit 3	15	12	14	13.6	12.7	85%
Unit 4	20	10	16	14.8	13.9	69%
Unit 5	25	12	15	14.4	13.5	54%
Total	75	43	56	53.4	50	67%

MISO (2024)

Marginal Accreditation

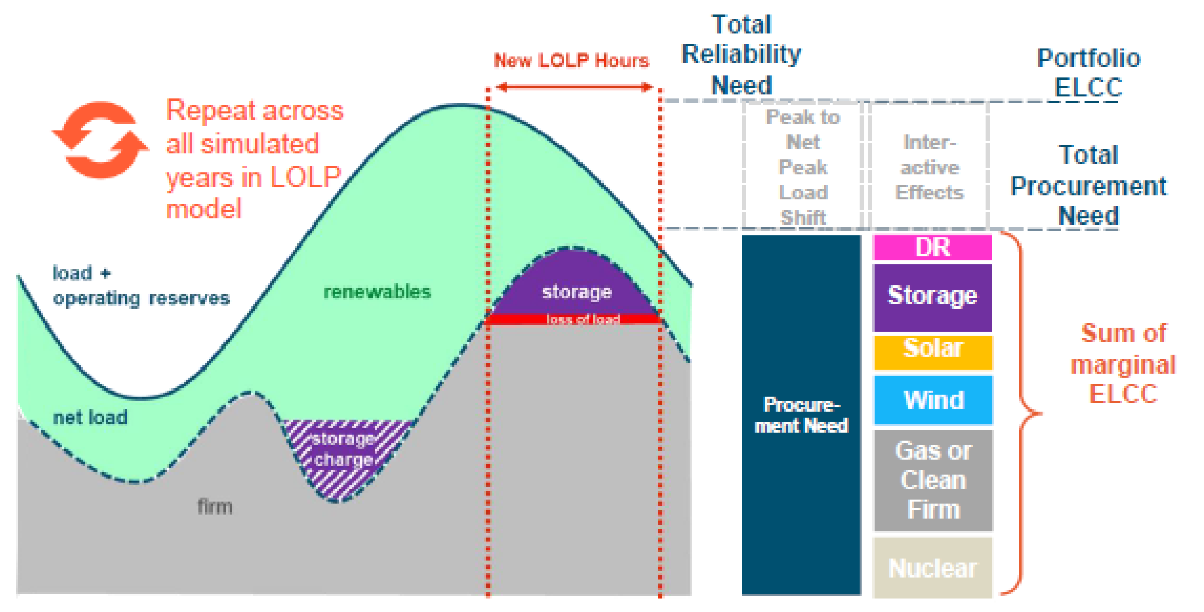
- Marginal approaches accredit a resource class (e.g., geothermal power plants) based on the incremental benefit of a small addition of this class relative to the portfolio of interest.
- Provides the most economically efficient pricing signal and an effective investment signal. For this reason, it has been adopted by NYISO, ISO-NE, PJM, and CAISO.
- However:
  - Accredited capacity is not fixed but rather a function of the system. Saturation can occur quickly. This is similar to other competitive energy markets.
  - Does not ascribe any value to solving past problems. How a past resource additions may have shifted the critical periods to a time in which it does not perform well is not acknowledged.
  - Does not equitably attribute value to resources which provided the energy for storage dispatch during critical periods.



FERC (2024)

Marginal Reliability Improvement (MRI)

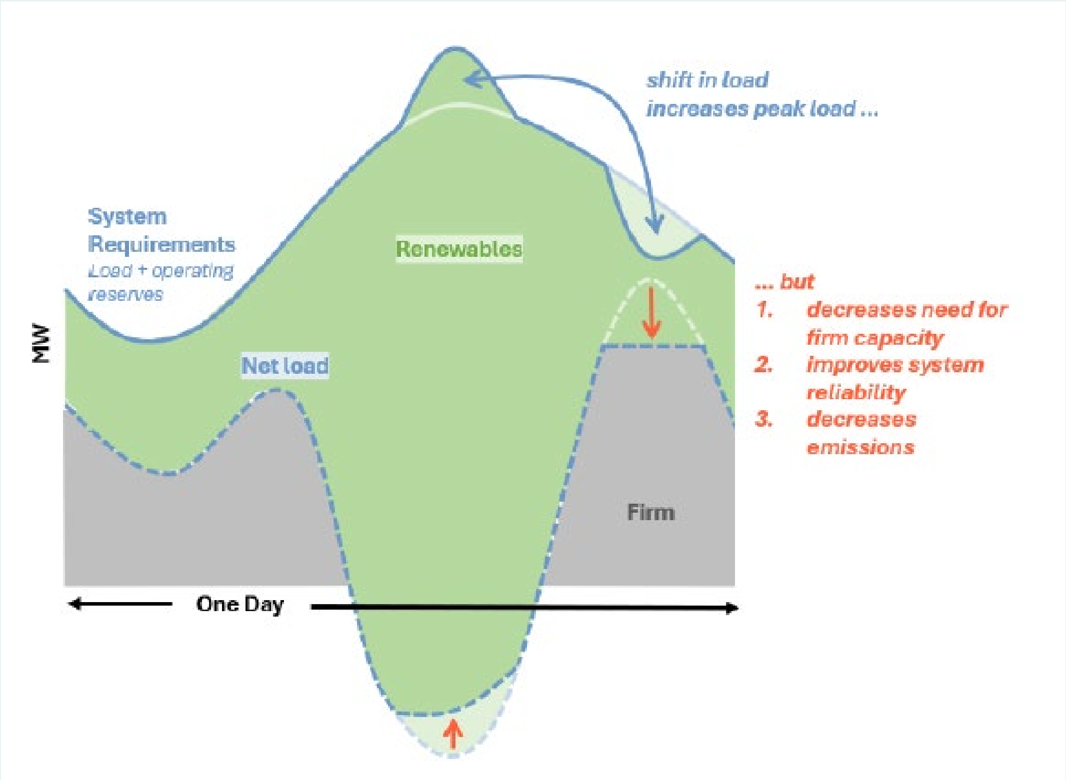
- Total Reliability Need (TRN) is based on perfect capacity to meet RA criterion
- Marginal ELCC calculations then inform how to meet the TRN with imperfect resources
- Summation of the MELCCs plus their interactive effects equal the TRN
- Summation of the MELCCs equals the Total *Procurement* Need
- Resource classes accredited at their MELCCs



Olsen et al. (2025a)

Load Participation in MRI

- Economically efficient signals for marginal demand allocation are also critical.
- Demand-side resources similarly must be considered during hours of tight margin rather than during peak.
- Load reduction during net peak is helpful for reliability. Conversely, load reduction during peak could diminish the ability of loads to respond when it matters most.
- Load participation in the implementation of MRI-based planning is lagging



Olson et al. (2025b)

Summary

- Resource accreditation guides resource evolution within regulated and restructured markets.
- Conventional accreditation relies upon nameplate capacity ratings of generation.
- Major shifts in the electricity system require new ways of valuing capacity.
- Current practice may incorporate deterministic or probabilistic, and retrospective or prospective approaches.
- Due to the potential saturation, diversity, and synergy of resources, best practice is to evaluate capacity as a combined portfolio effect.
- Marginal capacity, from the supply and demand sides, is emerging as an economically efficient method which can adapt to changes in the power system.

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DOE-funded Resources and Assistance for State Energy Offices and Regulators Program

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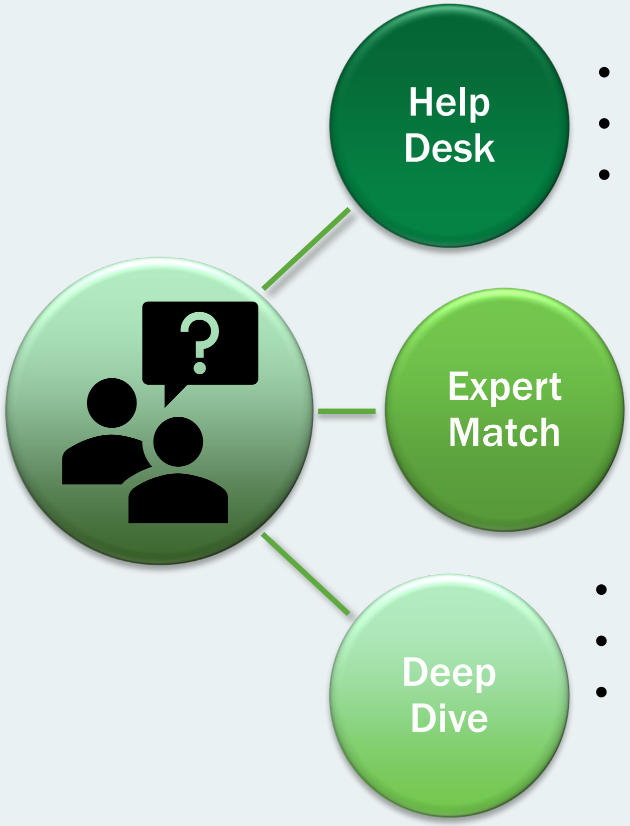

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- Detailed application form in planned ~6-month cycle
- Team of SMEs provide **100+ person-hours of support**
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