Assessing Capacity Accreditation Method Choice on Resource Mix Outcomes

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Presentation Outline

Project Motivation

Effective Load Carrying Capability

Varying storage dispatch strategies

Underlying risk metric selection

Marginal unit size

Direct Loss of Load

Marginal Reliability Impact

Critical hours definition

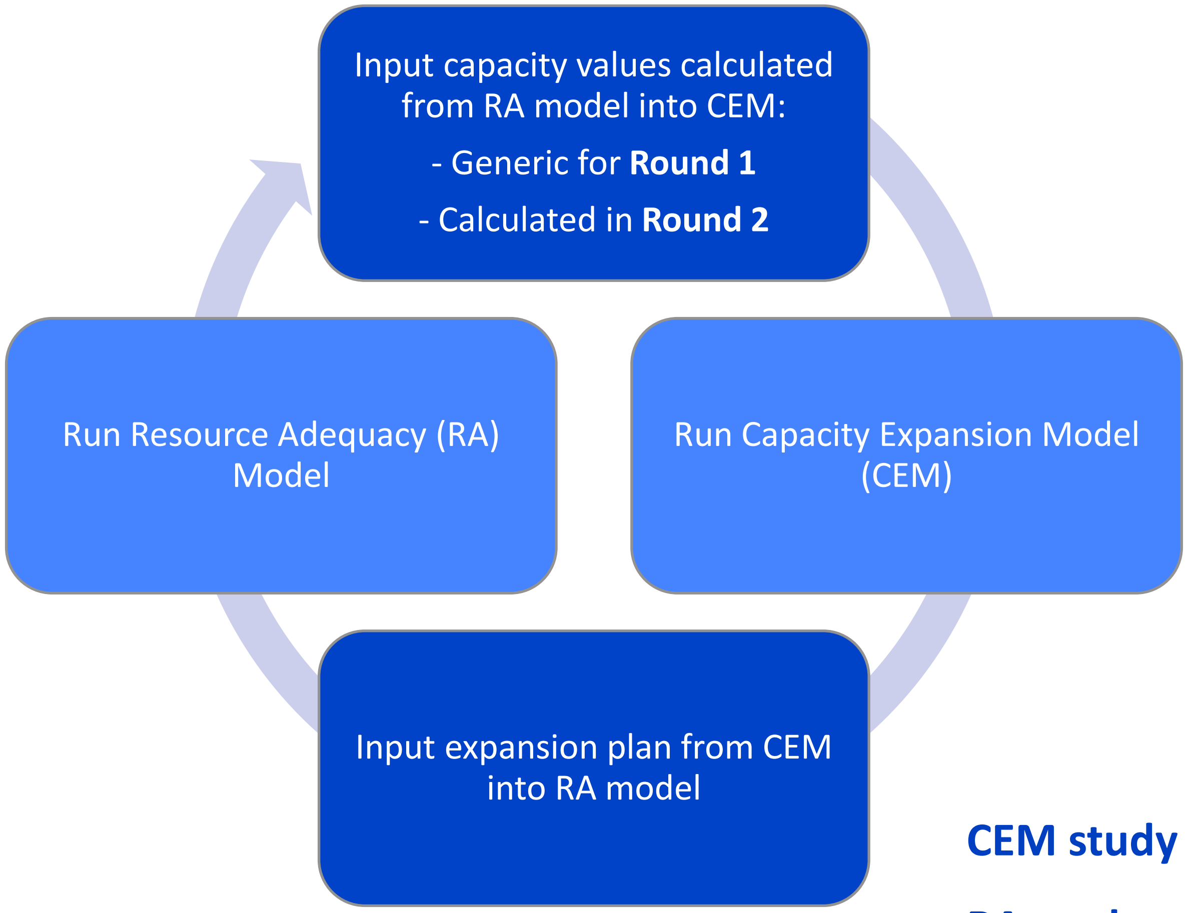
System hourly margin definition

Bringing a system to criterion

Risk hour weighting

Are these methods equivalent?

Modeling Approach: RA-CEM Round-Trip Analysis Process



Key Study Assumptions and Limitations:

- Capacity accreditation methodologies were evaluated for **wind resources only**.
- Capacity accreditation values were treated as **static** and did not vary with resource penetration levels or consider interactive effects between technologies.
- The coupled CEM–RA framework was executed for **two round-trip iterations**; iterative updating was **not extended to full convergence**.
- **Copper-plate system representation** was used (no explicit transmission modeling).

CEM study period: 2021-2040

RA study period: 2040

The study explores the CEM-RA round-trip analysis process by leveraging a Plexos model of a regional North American system.

Modeling Approach: Capacity Accreditation Methodologies Evaluated

Capacity Accreditation Metrics Evaluated

- **Effective Load Carrying Capability (ELCC):** Defined as the amount by which the system load must increase when the resource is added to the system to maintain the same system adequacy level.
- **Equivalent Firm Capacity (EFC):** Defined as the amount of firm capacity needed to replace the resource while maintaining the same system adequacy level.
- **Marginal Reliability Impact (MRI):** Defined as the impact on system adequacy of an incremental addition of installed resource capacity as compared to an equivalent amount of firm capacity additions.
- **Critical Periods Capacity Factor (CPCF):** Defined as the average resource availability during periods of elevated adequacy risk.

Methodological Variations Evaluated

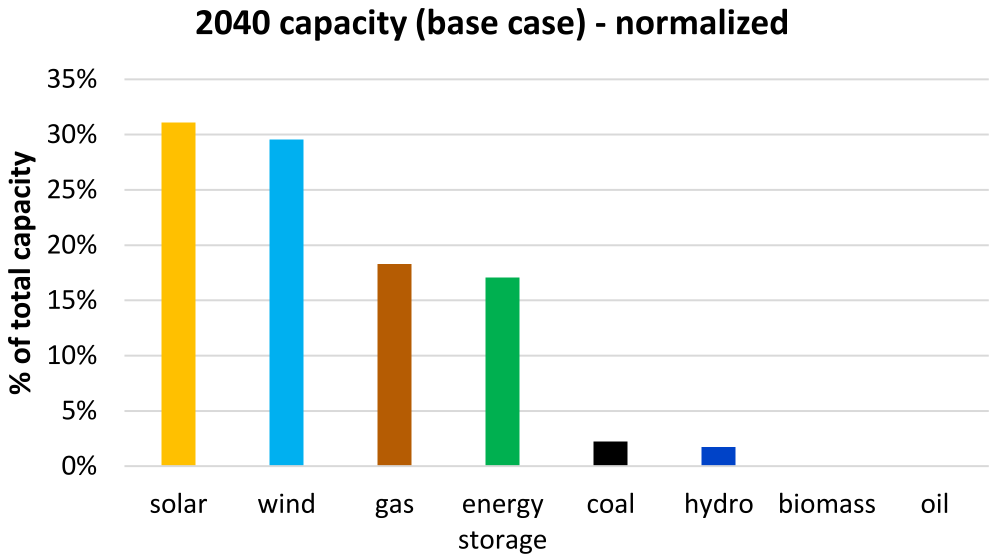
- Sensitivity of **ELCC, EFC, and MRI** to alternative underlying risk metrics (LOLE, LOLH, and EUE).
- Alternative formulations for calculating **CPCF**.

System Base Case Definition

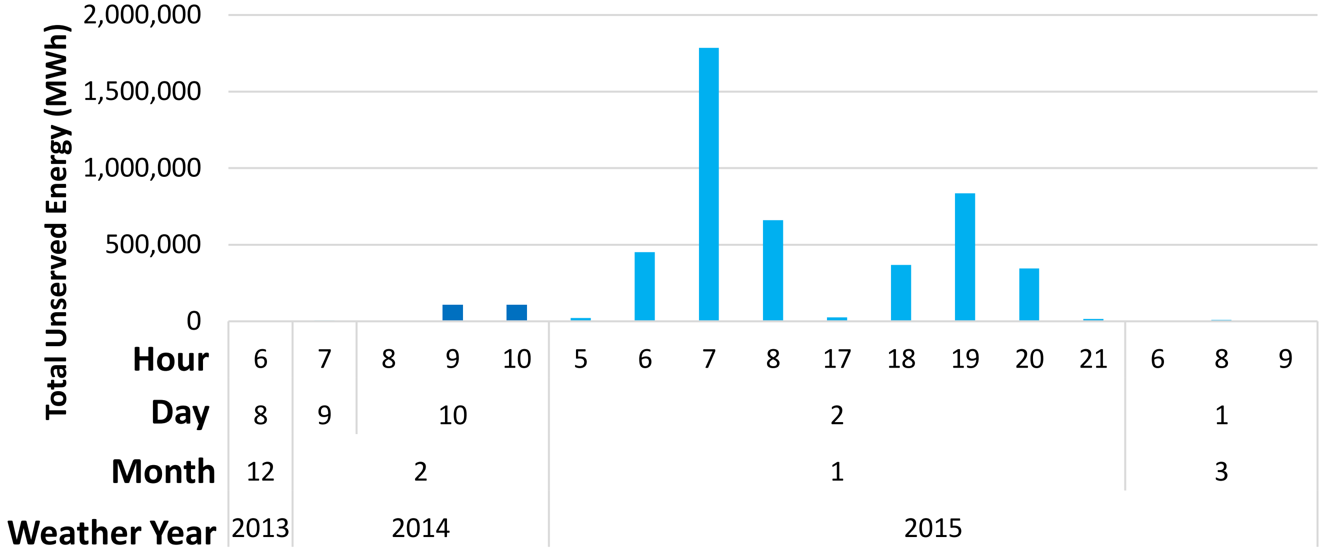
- Assessment of the impact on capacity values of cases **brought to a 0.1 days/year LOLE criterion** versus **cases not adjusted to criterion**.

The RA–CEM round-trip analysis process was applied across multiple capacity accreditation methodologies.

Key RA Metrics for System Base Case



System base case here is defined as the result of the CEM run with generic capacity values.



Unserved energy by weather year and hour of year

RA Risk Metric	2040 RA risk value
Expected Unserved Energy (EUE)	3,518 MWh/year
Loss of Load Expectation (LOLE)	0.20 days/year
Loss of Load Hours (LOLH)	0.74 hours/year

RA analysis was run for 9 weather years at 150 outage draws each, for a total of 1,350 samples.

2040 base case system doesn't meet the 0.1 days/year LOLE criterion

Unserved energy is concentrated in a very small number of hours and days.

Impact of Storage Dispatch Strategies on Base Case Results

Storage Dispatch Strategies

Greedy response: Storage is dispatched as soon as the system is at risk of an unserved energy event
Cost minimization: Storage is dispatched economically, to minimize total system costs
Min LOLH: Shortfall hours are minimized in this dispatch method
Min residual shortfall: Shortfall is distributed more evenly across hours to ensure no single hour sees a high shortfall

Storage Dispatch Method	Greedy response	Cost minimization	Min LOLH	Min residual shortfall
EUE (MWh/year)	3,518	3,511	3,599	3,518
LOLE (days/year)	0.199	0.231	0.300	0.316
LOLH (hours/year)	0.74	1.02	0.66	3.60

The greedy response was chosen for future runs, as it allows for a more intuitive storage behavior that is easier to track and more closely resembles market operations.

While EUE across storage dispatch strategies is stable, LOLE and LOLH vary quite significantly from one method to the other.

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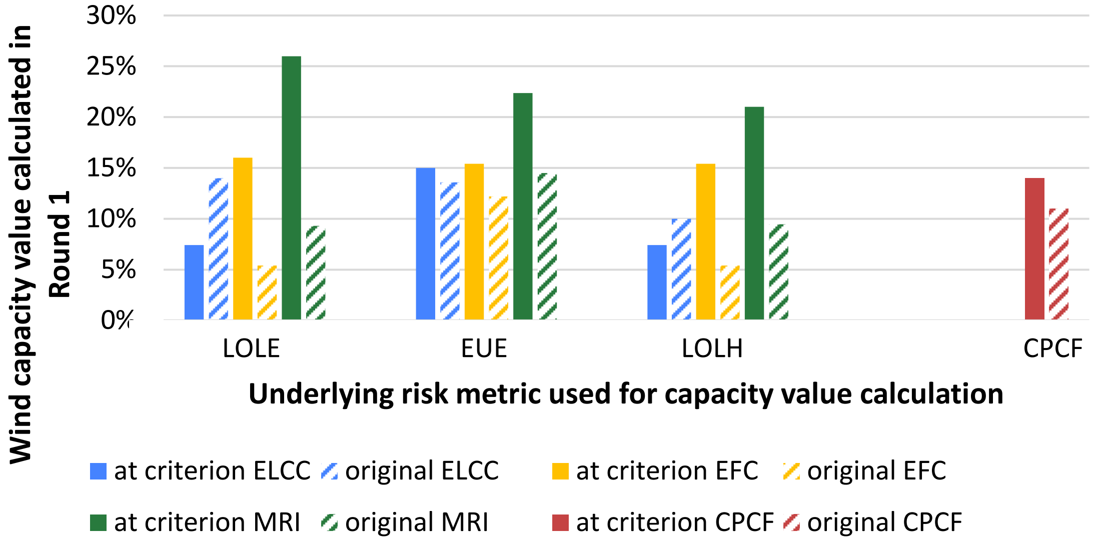
Wind Capacity Accreditation Values

Accreditation Metric	Underlying Risk Metric	Original	At criterion
ELCC	EUE	14%	15%
	LOLE	14%	7%
	LOLH	10%	7%
EFC	EUE	12%	15%
	LOLE	5%	16%
	LOLH	5%	15%
MRI	EUE	14%	22%
	LOLE	9%	26%
	LOLH	9%	21%
CPCF	N/A	14%	11%



- Wind capacity accreditation values **vary considerably across methodologies**.
  - Concentrated loss-of-load hours and high energy-storage penetration amplify sensitivity to small capacity buildout changes.
- **'At criterion' capacity accreditation values show a wider spread** that 'original' capacity values.
  - Bringing a case to criterion fundamentally alters system composition, affecting resulting capacity values.
- **EUE-based capacity accreditation metrics exhibit less variability** than those calculated using LOLE or LOLH.
  - LOLE and LOLH are more sensitive to temporal risk shifting, particularly in systems with high energy storage penetration.

Analysis of capacity accreditation results suggests that using the 'original' resource buildout and calculating accreditation metrics using EUE yields the most stable capacity values across methods.

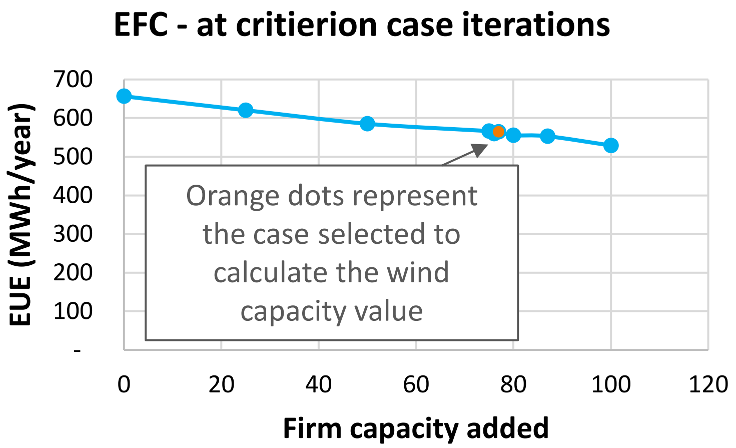
Impact of Marginal Unit Size Selection on MRI Results

Accreditation Metric	Underlying Risk Metric	Original	At criterion
MRI calculated with 500 MW marginal unit	EUE	14%	22%
	LOLE	9%	26%
	LOLH	9%	21%
MRI calculated with 100 MW marginal unit	EUE	14%	22%
	LOLE	20%	33%
	LOLH	22%	22%

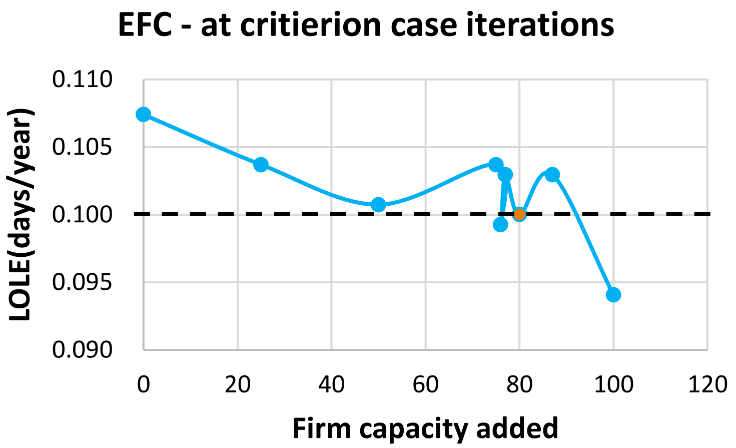
MRI calculated with **EUE as the underlying metric is consistent** across marginal unit sizes. However, MRI calculated using LOLE or LOLH as an underlying metric varies significantly depending on the size of the marginal unit selected for the calculation.

Preliminary results; further evaluation across marginal unit sizes and accreditation methods is warranted.

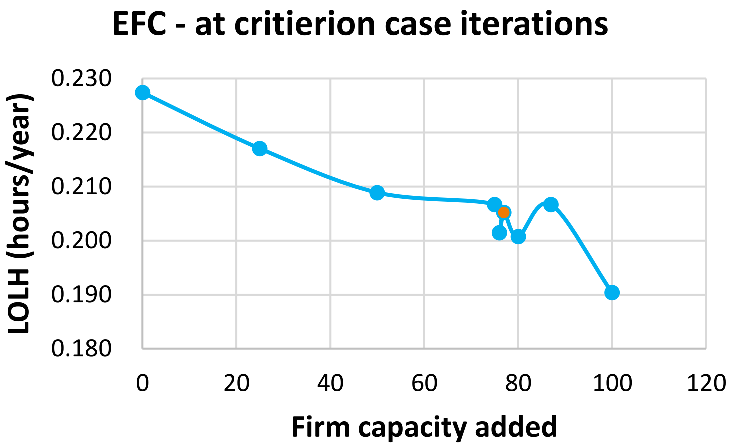
Challenges of Iterative Capacity Accreditation Methods with Optimization-Based Tools



As firm capacity is added to the system, EUE decreases monotonically.



As firm capacity is added to the system, LOLE does not decrease monotonically, as would be expected.



As firm capacity is added to the system, LOLH does not decrease monotonically, as would be expected.

The resource adequacy tool used for this analysis minimizes system cost, not LOLE or LOLH, so small changes in system dispatch can lead to a counterintuitive shift in the timing of shortfalls. However, because unserved energy carries a large penalty cost, EUE is effectively minimized through the optimization.

Iteratively calculating ELCC and EFC is straightforward when using EUE as an underlying risk metric but can be counter-intuitive when using LOLE or LOLH.

Critical Period Capacity Factor Analysis

Critical Periods Capacity Factor (CPCF): Average resource availability during periods of elevated adequacy risk.

Sensitivities evaluated

Critical periods: Unserved-energy hours vs. **low-margin (<3% of load) hours**.

Averaging: Unweighted vs. **severity-weighted** CPCF.

Storage contribution to system hourly margin:

Conditional Capacity Method: Storage contributes either its full discharge capacity (if energy-sufficient for the hour) or its net generation (if it fully discharges during the hour).

Net Generation Method: Storage contributes net generation in all hours; this approach avoids potential double-counting when storage shifts energy to higher-risk hours.

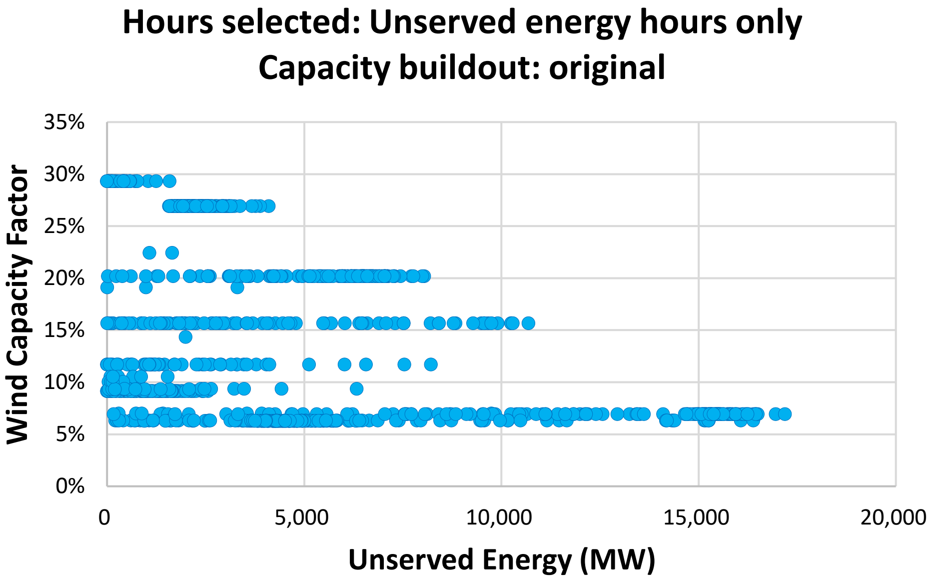
Hours selected	Average	Energy storage margin contribution calculation	Original	At criterion
Unserved energy hours only	Unweighted	N/A	14.1%	11.4%
Unserved energy hours only	Weighted	N/A	11.5%	10.2%
Low margin hours	Unweighted	Conditional capacity method	16.1%	15.1%
Low margin hours	Weighted	Conditional capacity method	12.8%	12.6%
Low margin hours	Unweighted	Net generation method	16.4%	15.6%
Low margin hours	Weighted	Net generation method	15.4%	15.0%

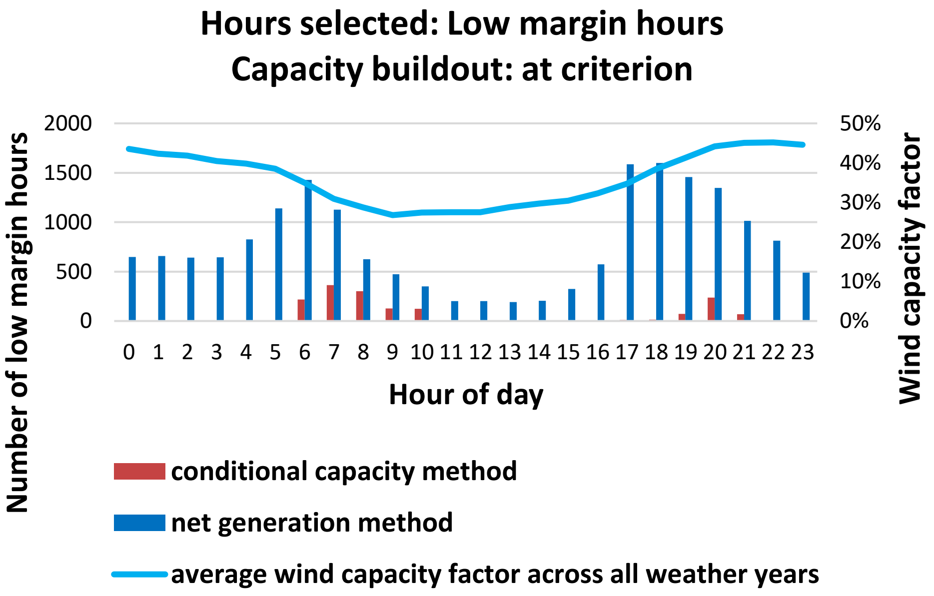
Sensitivity evaluated against ELCC, EFC, MRI methods

Calculated capacity values are sensitive to system margin definitions, critical period selection, averaging approach, and whether the system is brought to adequacy criterion.

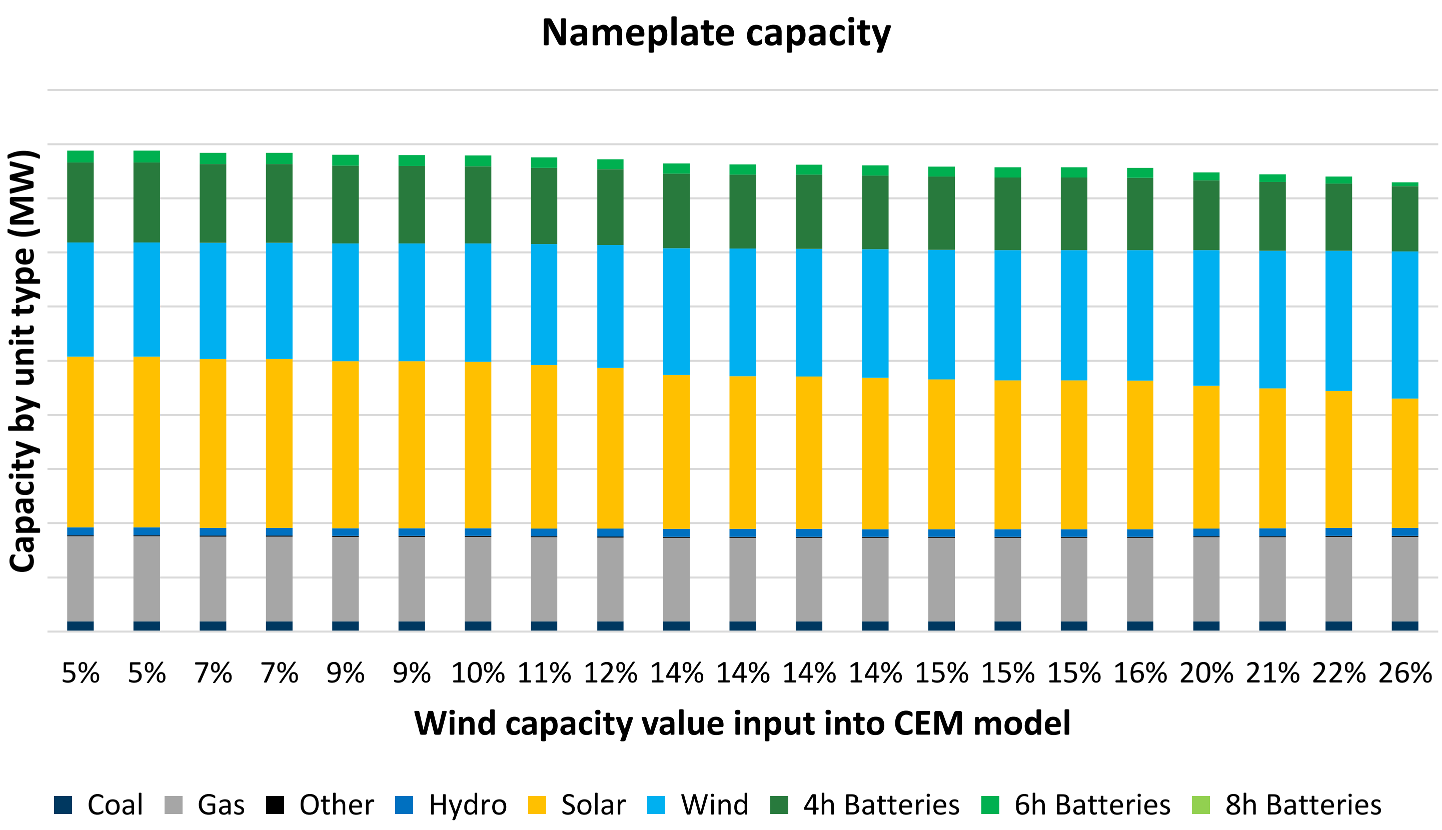
Understanding Differences in CPCF Results

- The most critical adequacy hours tend to align with **lower wind availability**, which leads to:
  - Lower capacity values when critical periods are **severity-weighted** instead of using an **unweighted average**.
  - Lower capacity values from **unserved-energy-only methods** relative to **low-margin hour methods**.
  - Lower capacity values in the **at-criterion capacity buildout case** compared to the **original case**, because capacity was added to bring the case to criterion, resolving less-severe adequacy events and leaving only the most severe events, which tend to occur during low-wind conditions.
- Using a **larger and more diverse set of hours** reduces sensitivity to individual high-risk events, resulting in:
  - More stable capacity values for **low-margin hour methods**.
- The **storage contribution-to-margin approach** has a limited impact on capacity values. The net-generation method produces slightly higher values by identifying additional low-margin hours, which often occur overnight when wind output is stronger.





Capacity Expansion Buildout Results



Horizontal axis values correspond to Round 1 wind capacity accreditation results used as CEM inputs.

Higher wind capacity value assumptions in the CEM result in greater wind buildout. Increased wind deployment primarily displaces solar and battery builds, while gas capacity remains relatively stable.

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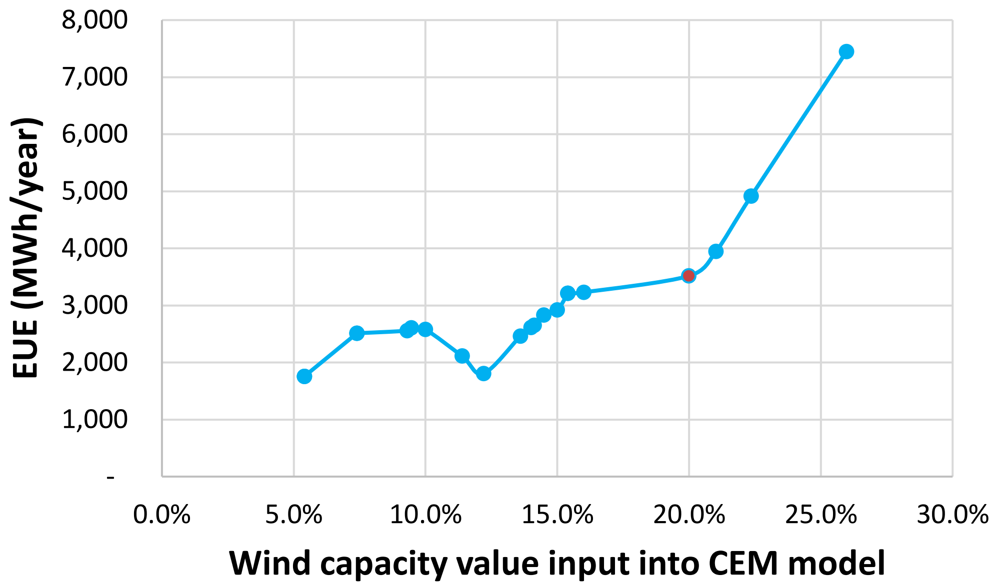
Why Adequacy Risk Period Timing Matters in CEM Results



Simplified capacity expansion models do not explicitly plan for highest-risk periods, even though loss-of-load timing strongly influences which capacity buildout choices are most beneficial.

Small changes in inputs to CEMs can lead to large differences in CEM results, as the least-cost optimal resource switches from one resource to another.

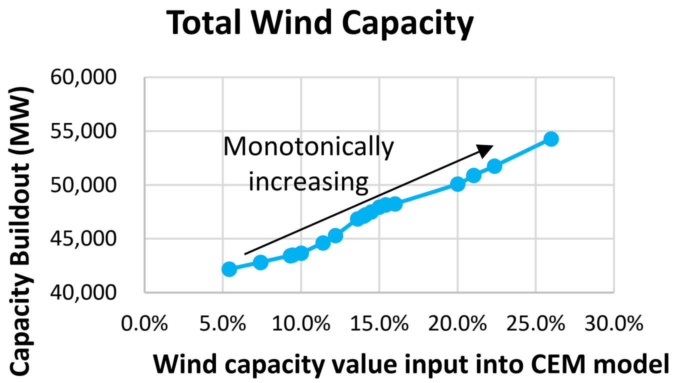
The impact on system adequacy of substituting between solar and wind resources depends on the timing of the adequacy event:

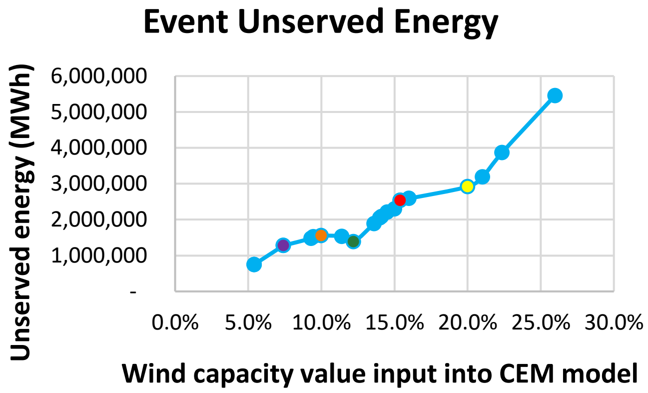
- For **early-morning events**, additional wind improves reliability both through direct generation during the event and by charging storage beforehand.
- For **evening events**, impacts are more nuanced: solar can contribute earlier in the day by charging storage but is unavailable during the event itself, making wind capacity more useful at event hours.

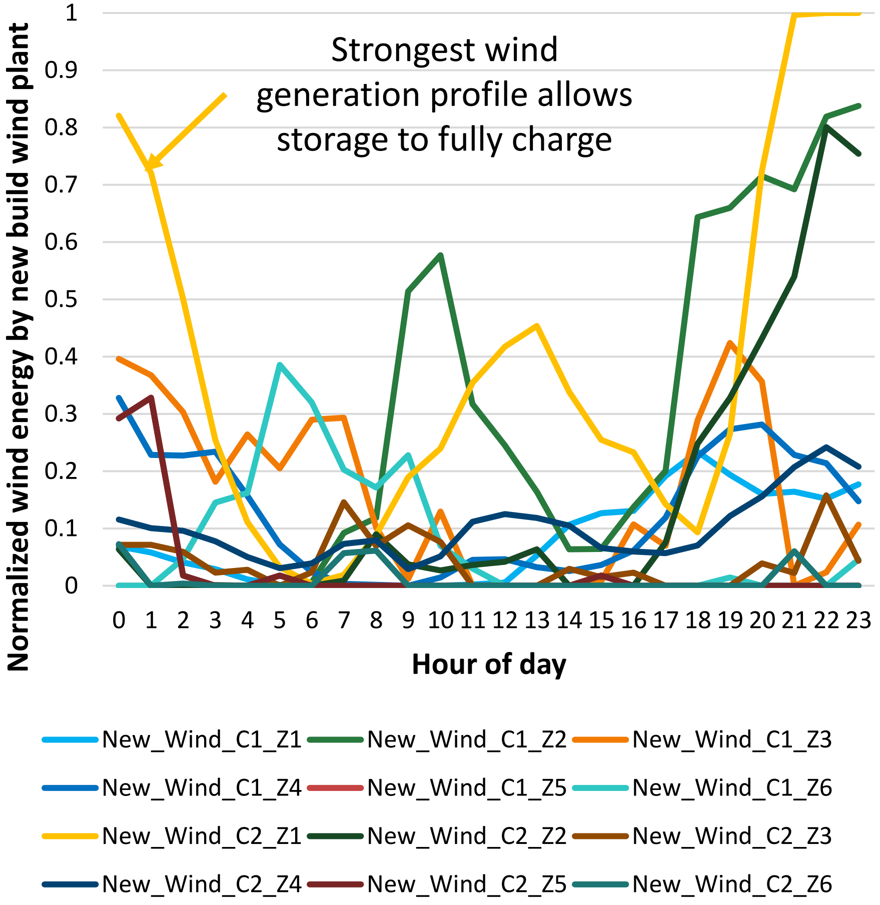
Wind capacity values input into the CEM do not show a direct correlation with the resulting adequacy of the system.

Importance of Incorporating Locational Capacity Values Within the CEM

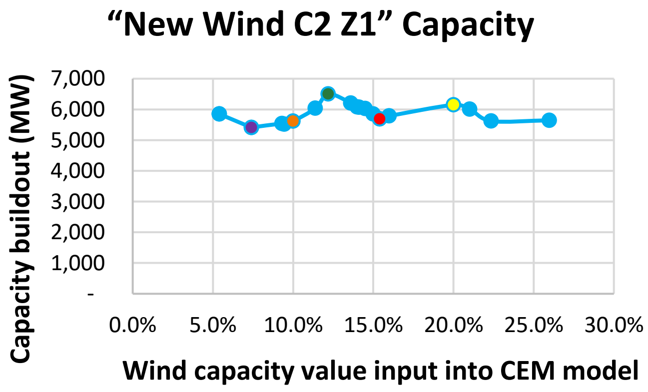
Analysis of the largest adequacy event: January 2 AM event (2015 weather year)







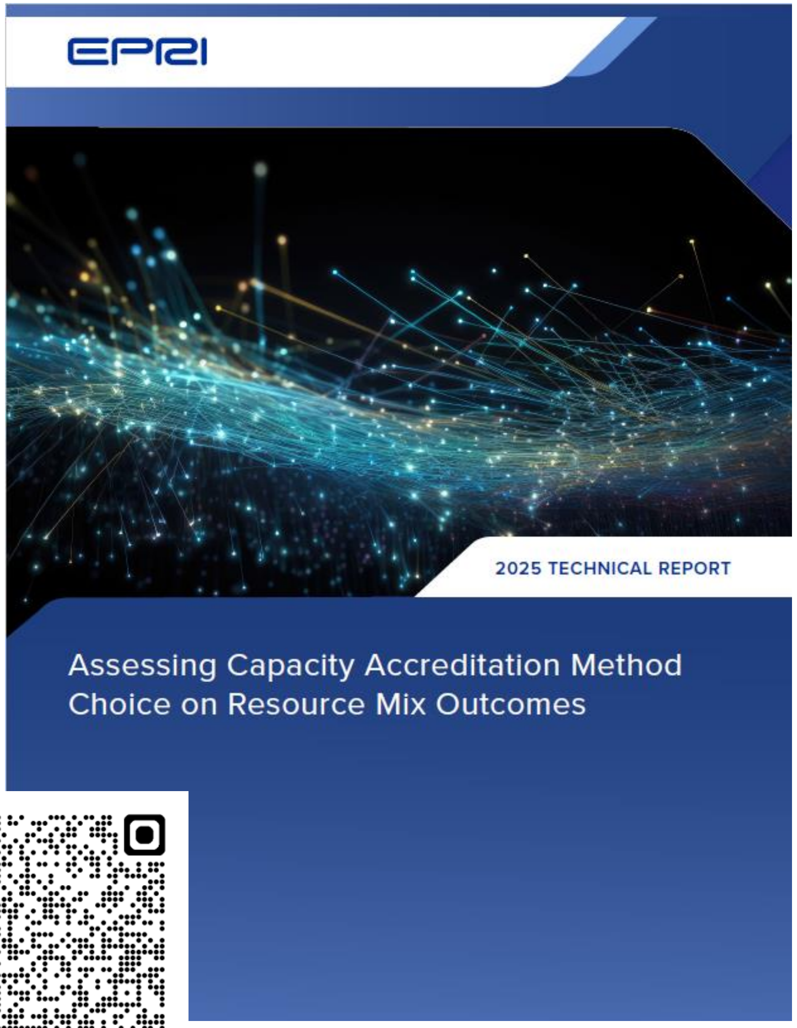
- Despite increased wind buildout, unserved energy during this early-morning event does not decrease monotonically as wind capacity value input into the CEM model increases.
- Higher buildout of the “New Wind C2 Z1”plant improves reliability due to strong overnight output, influencing system EUE.



Adequacy depends on which specific wind plants the CEM selected and their output during certain high-risk hours.

Key Takeaways

- **Capacity accreditation values were highly sensitive to methodological choices**, including the choice of accreditation metric, underlying risk metric, and whether the system was brought to criterion.
- **EUE-based capacity accreditation methods exhibited greater stability** than LOLE- or LOLH-based methods.
- **Capacity accreditation methodologies materially shape capacity expansion outcomes**, underscoring the need for greater transparency and consistency in how accreditation metrics are defined and applied.
- **Results highlight the importance of incorporating locational capacity values for wind into CEMs**, as the temporal alignment of individual plant availability with system stress periods materially influenced adequacy outcomes.
- **Explicitly representing adequacy risk timing and severity in CEMs could improve resource build decisions** by more tightly linking CEM and RA models, since optimal capacity buildouts depend on when and where loss-of-load occurs.



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