Resource Adequacy Initiative

Key Outcomes and Next Steps

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The Resource Adequacy Challenge

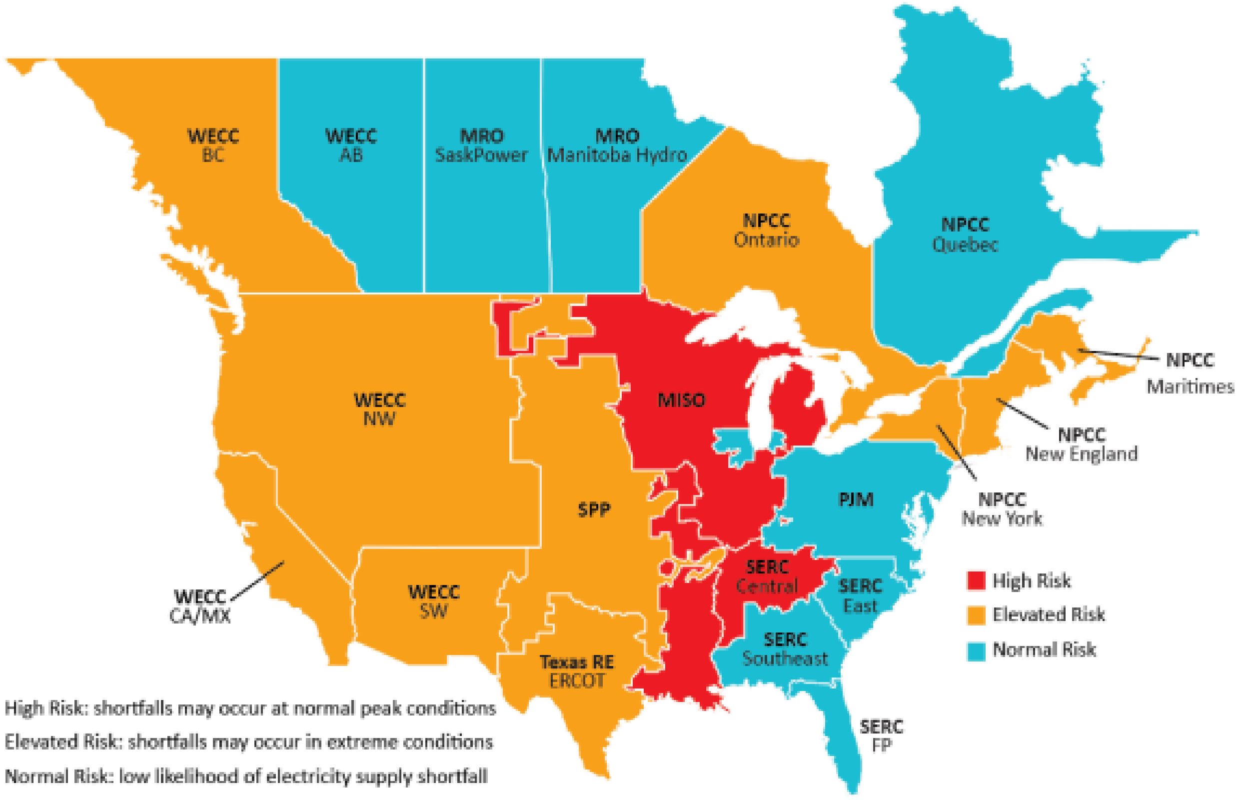

Figure 1: Risk Area Summary 2024–2028[8]

Recent events challenging adequacy:

- [Winter Storm Uri (2021)]
- [Winter Storm Elliott (2022)]
- [Winter Storms Gerri/Heather (2024)]

2023 NERC Long Term Reliability Assessment identified:

- Increasing (elevated/high) risk in many North American regions
- Winter fuel supply challenges
- Capacity reserve challenges

Source: NERC Long Term Reliability Assessment (link)

EPRI Resource Adequacy Initiative

Scope and Deliverables

RA Process
- Recommended Metrics and Criteria
- Future Scenario Database and Tool

Models and Data
- Emerging Resource & Demand Side Models
- Model Data Development Tools

Analysis Tools
- Existing RA Tool Capabilities
- New Algorithms and open-source code

Case Studies	Evaluation of existing and development of new capabilities based on 4-6 regional RA case studies covering differing RA issues and tools.
Tech Transfer	Reports and workshops to be conducted to disseminate results and to promote broad adoption in commercial tools.

25+ Participants

Southern California Edison – Energy for What's Ahead; CPS Energy; Duke Energy; AECI – Associated Electric Cooperative Inc.; Hawaiian Electric; American Electric Power; LCRA; conEdison; Ameren; TVA; Austin Energy; New York State of Opportunity – NY Power Authority; Los Angeles Department of Water & Power (LADWP); Arkansas Electric Cooperative Corporation; Southern Company; SRP; NERC – North American Electric Reliability Corporation; MISO; SPP Southwest Power Pool; aps; ISO new england; pjm; Entergy; evergy; New York ISO – Independent System Operator; Manitoba Hydro; NPCC, Inc.

Partners

TELOS ENERGY; ASTRAPÉ CONSULTING – innovation in electric system planning; GE; MOMENT ENERGY INSIGHTS; Blue Marble Analytics; ENELYTIX® powered by PSO

External Advisory

NARUC, NREL, ESIG, GridPath, RROs, DOE, ISOs/RTOs, G-PST, Consultants, Universities, etc.)

Foundational Case Studies

Six case studies of future systems were carried out for different climate and electrification contexts to assess a range of key questions and study tool capabilities that are relevant for each region. All are intended to be future looks at how systems may evolve, and do not replace standard planning studies in the region

	WECC	TEXAS	SPP	MISO	Northeast	Southeast Utility
Metrics	●	●	●	●	●	●
WDO Modeling	○	●	○	●	●	○
Climate Impacts	○	○	○	○	●	○
Load Evolution	○	●	●	○	●	○
Storage	●	●	●	○	○	○
Transmission	○	○	○	●	●	○
Gas Electric	○	○	○	○	○	●

www.epri.com/resource-adequacy **for more details and free public reports**

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EPRI Resource Adequacy Decision Support Framework

The case studies, together with extensive review of other studies and consultation with industry stakeholders, provided the evidence base upon which a guideline and decision support framework was developed.

Strategic Guidance: Assessment Design Principles

Resource Adequacy Philosophy

Use this to:
→ Review the purpose and scope of resource adequacy assessments
→ Leverage foundational principles in process design
→ Compare existing assessment processes to verify completeness

Scenario Selection Guidance

Use this to:
→ Identify the range of variables and factors that may influence the outcome of adequacy assessments
→ Prioritize approach to considering each of the variables within assessment processes

Metrics & Criteria Guidance

Use this to:
→ Review the metrics and criteria used to measure adequacy around the world
→ Understand how metrics are calculated and the differences in the risk conveyed by the metrics

Tactical Decision Support: Study Execution Decision Support

Technology & System Models

Use this to:
→ Review methods by which supply and demand technologies are represented in adequacy models
→ Determine appropriate level of detail that is recommended for each asset type

Data Requirements

Use this to:
→ Review recommended data sources, variables, extent and quality required to parameterize models
→ Determine appropriate level of detail that is recommended for each variable

Assessment Tool Capabilities

Use this to:
→ Review the analysis capabilities of commonly applied resource adequacy assessment tools
→ Compare the approaches applied within each, in the context of the recommended model and data guidance

Research Gaps

Resource Adequacy Gap Assessment

Use this to:
→ Understand the unmet challenges faced by resource adequacy stakeholders, with prioritization of next tasks.

Metrics Recommendations

1. Reduce reliance on a single metric
2. Consider top percentiles and outlier events
3. Better leverage existing metrics
4. Describe characteristics of involuntary load shedding events

These recommendations shouldn't be particularly new to those who have been following!

The EPRI Resource Adequacy Initiative Case Studies demonstrate these recommendations in regions across North America.

Criteria Setting Considerations

1. Adequacy exists on a spectrum and should not be a binary choice
2. Criteria setting should not be conducted independent of economic assessment
3. Reliability criteria may need to be updated to meet customer expectations as the nature of risk changes
4. There is no universal criterion for an adequate system

In a lot of ways, this is the more challenging part!

These criteria setting considerations are further detailed in the publicly-available EPRI report: *Metrics and Criteria: Insights from Case Studies and Recommendations and Considerations for Future Practice* (3002030638)

Modeling Energy Storage – Capabilities Needed

Dispatch objectives:
1. Economics
2. Reliability (heuristics-based Monte Carlo solvers)
3. Peak shaving

Some tools have a multi-purpose dispatch objective!

For optimization-based Monte Carlo solvers:
- Optimization window
- Penalty on storage state-of-charge depletion

Energy Reservoir Model
- Energy capacity
- Power capacity
- Roundtrip efficiency

Efficiency:
- Roundtrip charging/discharging efficiency
- 'Self-discharge'/'carry-over' efficiency

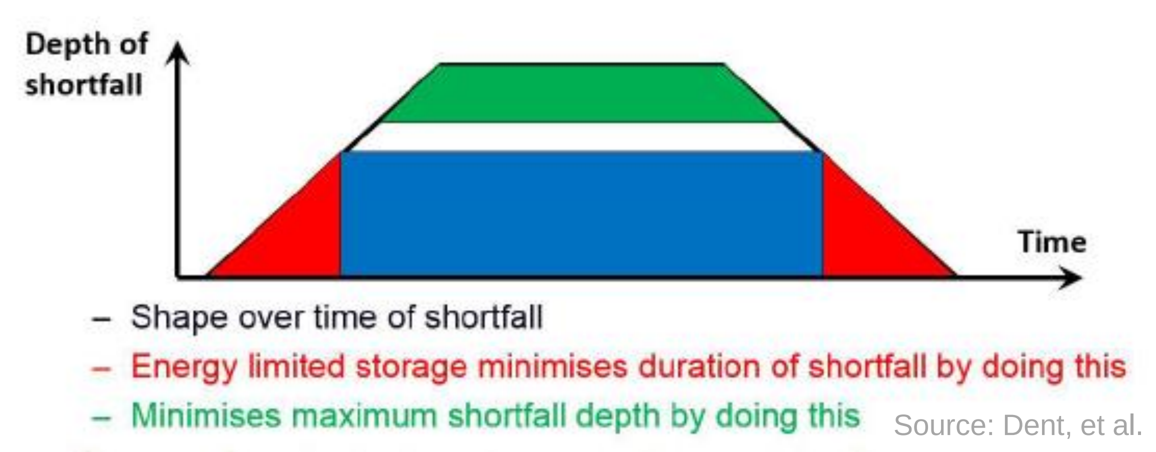
State-of-charge:
1. Continuously monitored
2. Only monitored during at risk periods

Outage modeling:
1. Not explicitly modeled
2. Capacity derate
3. Probabilistic outage modeling

Additional constraints:
- Charging/discharging restrictions

Model/Data/Tools focused-papers provide key insights for assessing storage

Texas case study – Impact of storage scheduling options



Multiple objective functions considered in PLEXOS:

- **Economic:** minimize system cost (number of hours)
- **Min LOLEv:** minimize the number of events
- **First Come First Serve:** immediately discharge at max output as soon as unserved energy starts and do not hold energy for later periods (likely reflects actual operations, absent market intervention)
- **Min Shortfall:** minimize the depth of the shortfalls (max load unserved for any given hour, potential market operator intervention)

	Econ	Min LOLEv	First Serve	Min Shortfall
LOLE (days/yr)	0.103	0.103	0.082	0.105
LOLH (hours/yr)	0.387	0.438	0.230	0.557
EUE (MWh/yr)	**724.52**	**724.52**	**724.52**	**724.52**
Avg Depth (GW)	2.2	2.0	3.9	1.4
Max Depth (GW)	6.3	6.3	9.0	4.3
Avg Duration (hrs)	2.8	3.3	2.8	5.8

Note: Min LOLEv optimization did not result in lower LOLE than alternative methods due to step size and optimization horizon, and different definitions of event classification (i.e. consecutive hours vs. days, etc.)

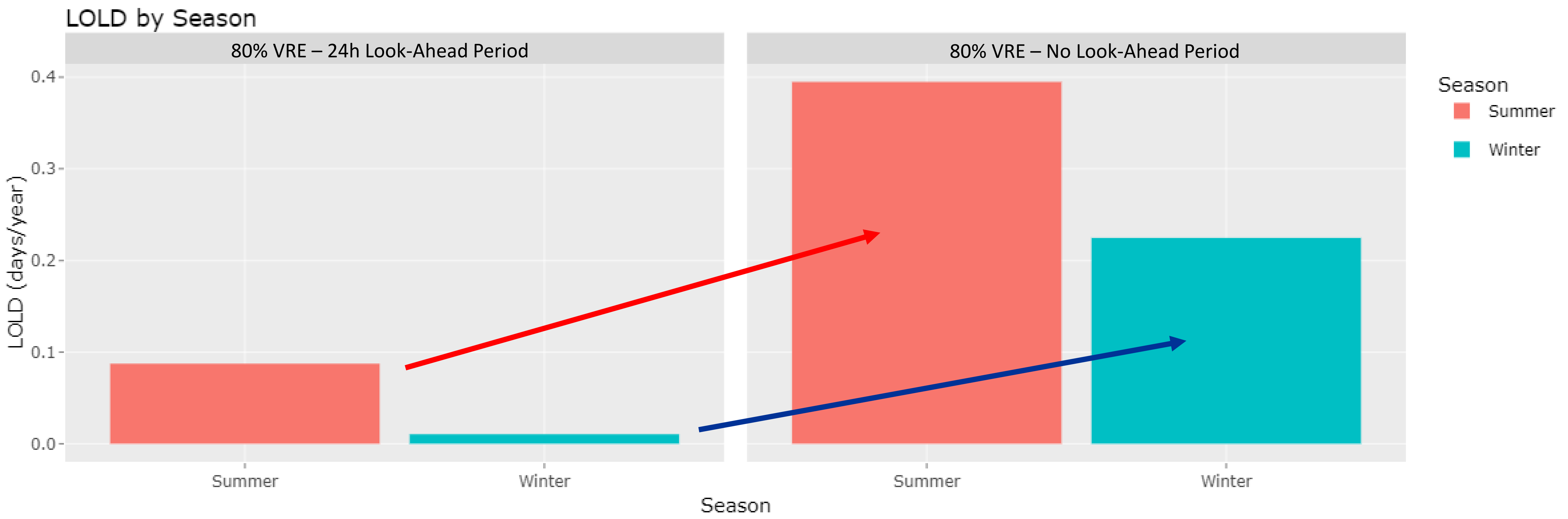
Different methods of dispatching batteries under scarcity conditions yield different results for LOLE but identical results for EUE

In an energy-constrained system, an energy metric (EUE) may be best suited for a new reliability criterion

[Link to Study]

SPP case study – modeling of look-ahead

Scenario	LOLH (hours/year)	LOLD or LOLE (days/year)	LOLP (%/year)	LOLEv (events/year)	EUE (MWh/year)	NEUE (ppm/year)
80%_VRE (24h look-ahead)	0.15	0.098	0.03	0.11	98	0.33
80%_VRE (no look-ahead)	2.05	0.619	0.17	0.74	1010	3.40



With less foresight, heightened risks are expected both in summer and in winter

Link to Study

Western US case study – Long-duration storage modeling

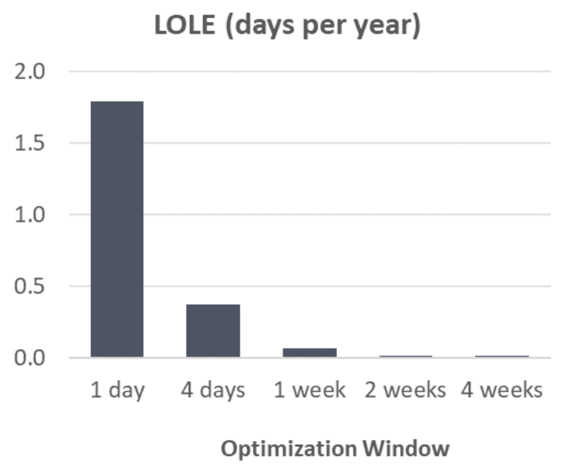
	Wind + Solar	Battery Storage	Generic Thermal	Multiday Storage
Portfolio 6	240 GW	60 GW (8 hrs)	0 GW	**43.2 GW (569 hrs)**

Default settings:

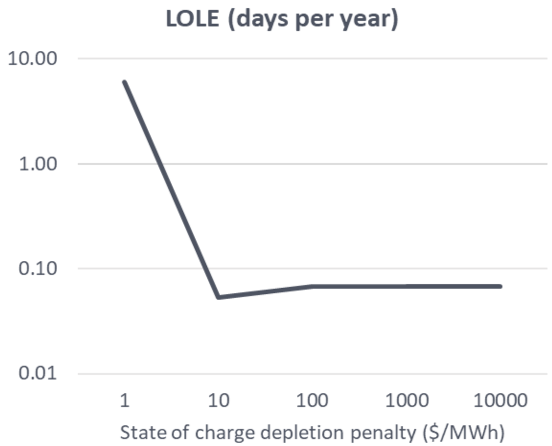
- Optimization window: 1 week
- State of charge depletion penalty: $100/MWh
- Simulation start date: Week 23 (June 4th)

- Longer optimization windows (i.e., more foresight) reduces RA risk across all metrics.
- For 1-week optimization window, state of charge depletion penalty in the last time step had to be at least $10/MWh to encourage the storage to adequately charge for future weeks.
- Beginning the simulation in June yields lower RA risk, aligns with more realistic operating practices, and reduced runtimes.

Optimization Window Tests

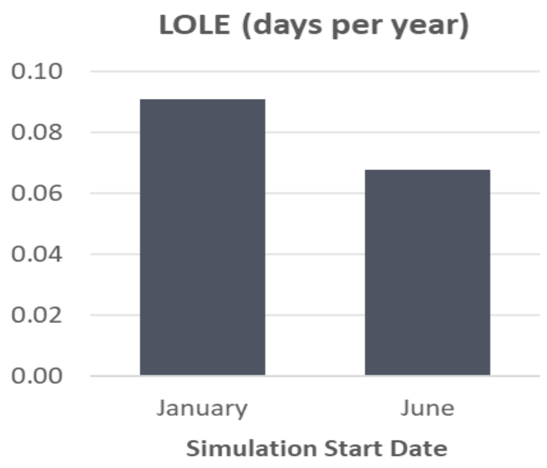


State of Charge Depletion Penalty Tests



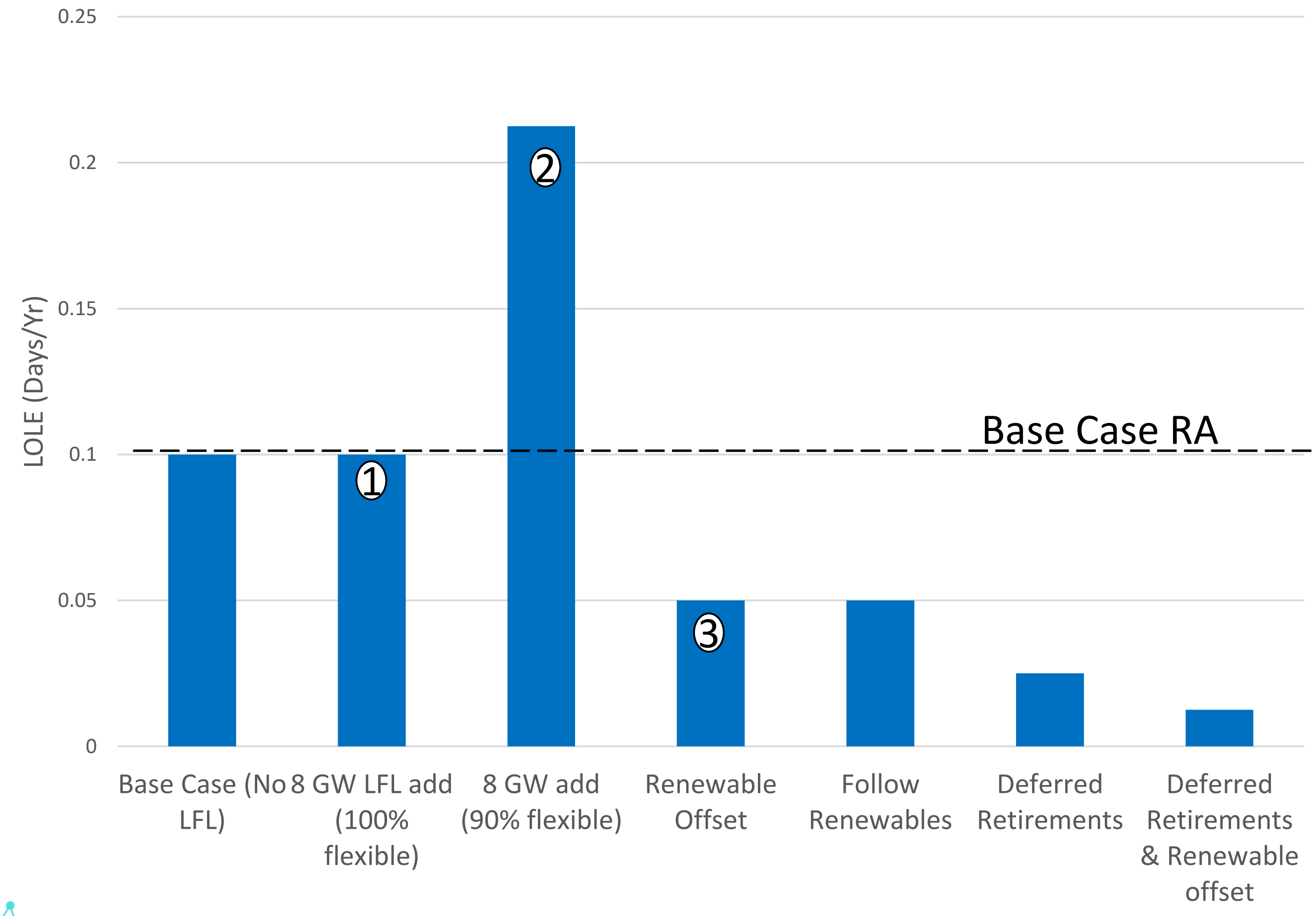
[Link to Study]

Simulation Start Date Tests



RA impacts from adding 8 GW of large load to ERCOT system

Link to Study



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1. Adding fully flexible load has neutral impact (used infrequently in most cases)
2. Observe significant impact on resource adequacy even if only 10% of new load is inflexible (require additional new resources)
3. If large flexible loads (LFL) incentivize a decrease in thermal generation retirements and/or renewable generation additions, loss of load risk is significantly reduced, with compounding benefits.

Reliability impacts vary with tariff/data center, operating profile and interactions with system

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Resource Adequacy – Current Key Issues We Have a Good Handle On

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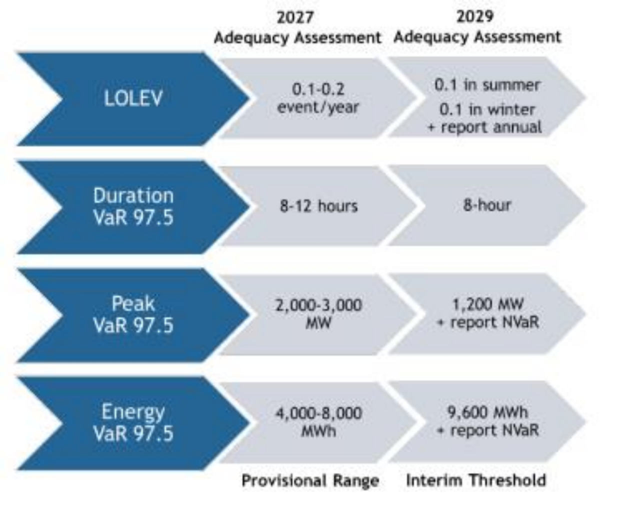
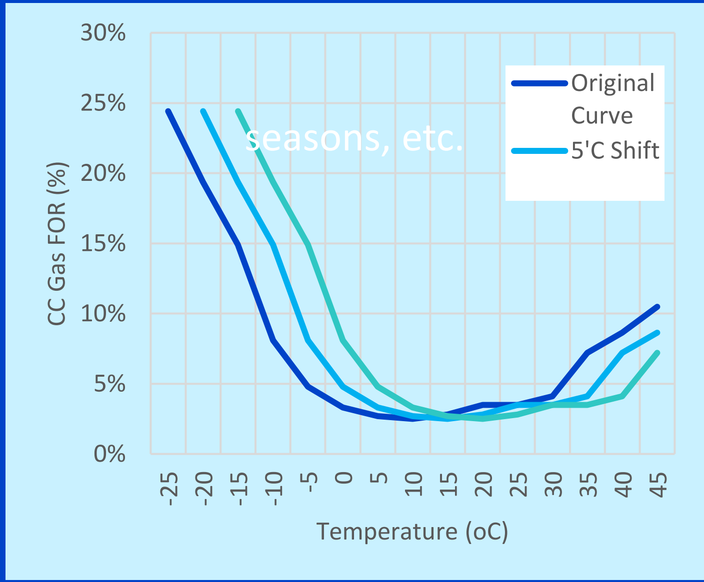
- **Additional metrics/ criteria needed to assess adequacy risk**



From NWPCC Power Supply Adequacy Assessment

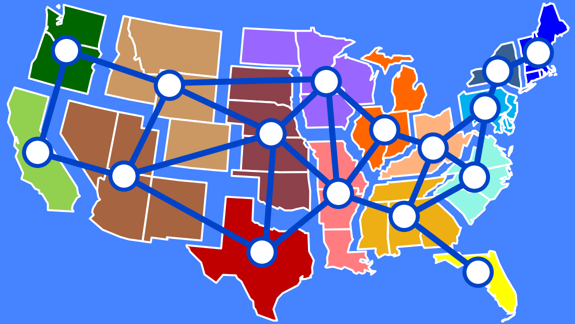
ERCOT multiple metrics
MISO seasonal RA construct
NWPCC multiple metrics

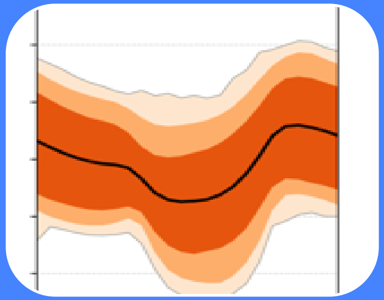
- **Need to consider range of operational conditions and resource behavior**



Weather dependence in PJM
Flexibility requirements in CA

- **Need more comprehensive data and models**





ESIG dataset report
ENTSO-E ERAA datasets/scenarios

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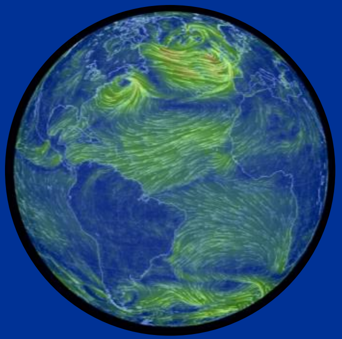
What are things we know less about?

- **How do we consider extreme events and climate change?**



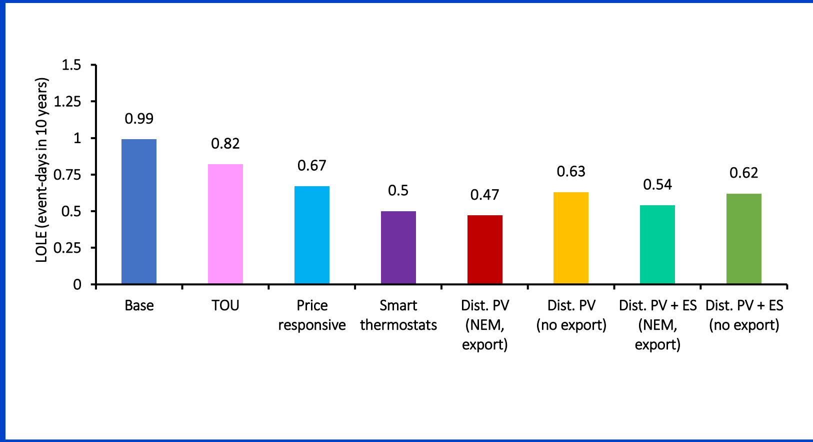
Cold Snap

Severe Storm

Heatwave

EPRI/ISO-NE Risk Screening
Extreme events in NWPCC, etc.

- **How do we include changes in load – demand flexibility, electrification, etc.?**



Data Center Flexibility
VPP flexibility

- **How can we better assess resource contribution to system reliability?**

Capacity accreditation updates in many ISO/RTOs
Ongoing EPRI/NREL work w/DOE

RA Knowledge Center – Ongoing

Goal

To provide clear, complete and insightful information to support practitioners in their selection of methods to assess resource adequacy.

https://gridops.epri.com/Adequacy

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