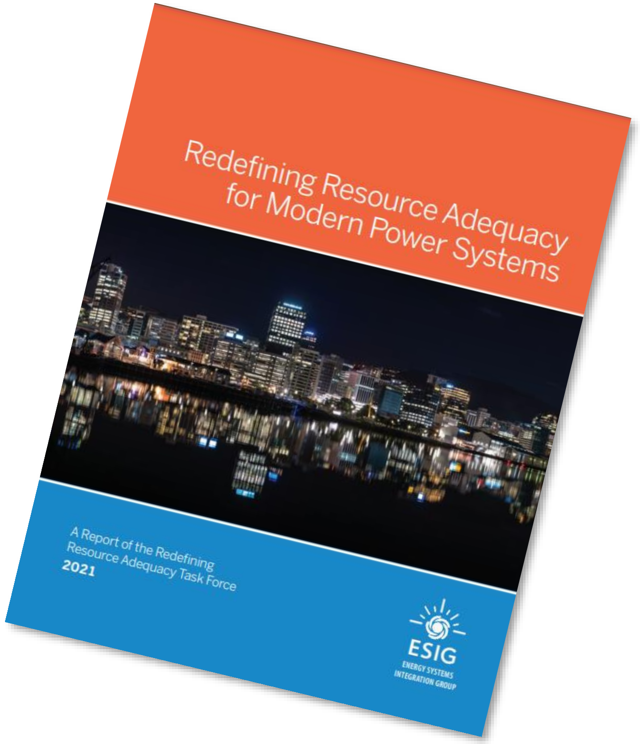
Beyond 1-day-in-10

Four Recommendations for Improved Use of Resource Adequacy Metrics

ESIG Fall Workshop | 10/7/2021

TELOS ENERGY

Acknowledgements



ESIG Whitepaper: Redefining Resource Adequacy for Modern Power Systems

ESIG Blog: Five Principles of Resource Adequacy for Modern Power Systems

ESIG Webinar: Redefining Resource Adequacy for Modern Power Systems

This project is supported by the Energy Systems Integration Group (ESIG), as part of the Redefining Resource Adequacy Task Force. The contents of this presentation are solely the responsibility of the authors and do not necessarily represent the official views of ESIG or its members

» **Next Steps:**
- Whitepaper on Evolving Metrics
- Policy Brief for GPST & COP26

Six principles of resource adequacy for modern power systems

1. Quantifying size, frequency and duration of outages is critical to finding the right resource solutions.
2. There is no such thing as perfect capacity.
3. Modeling chronological operations is essential for modern power systems.
4. Load participation fundamentally changes the resource adequacy construct.
5. Neighboring grids and transmission are a key part of the RA challenge
6. Reliability criterion should not be arbitrary, but transparent and economic.

New Metrics for Resource Adequacy

New metrics or deeper metrics? How to measure RA.

Where are we today with RA metrics?

- Most regions in North America use a 0.1 days/year LOLE metric as the reliability criteria
- "Line in the Sand Syndrome"
- Little understanding / transparency into why, or the costs of achieving reliability
- Other RA metrics rarely reported or deemphasized
- May have been appropriate for historic grid, where risk was largely driven by random generator outages and load variability

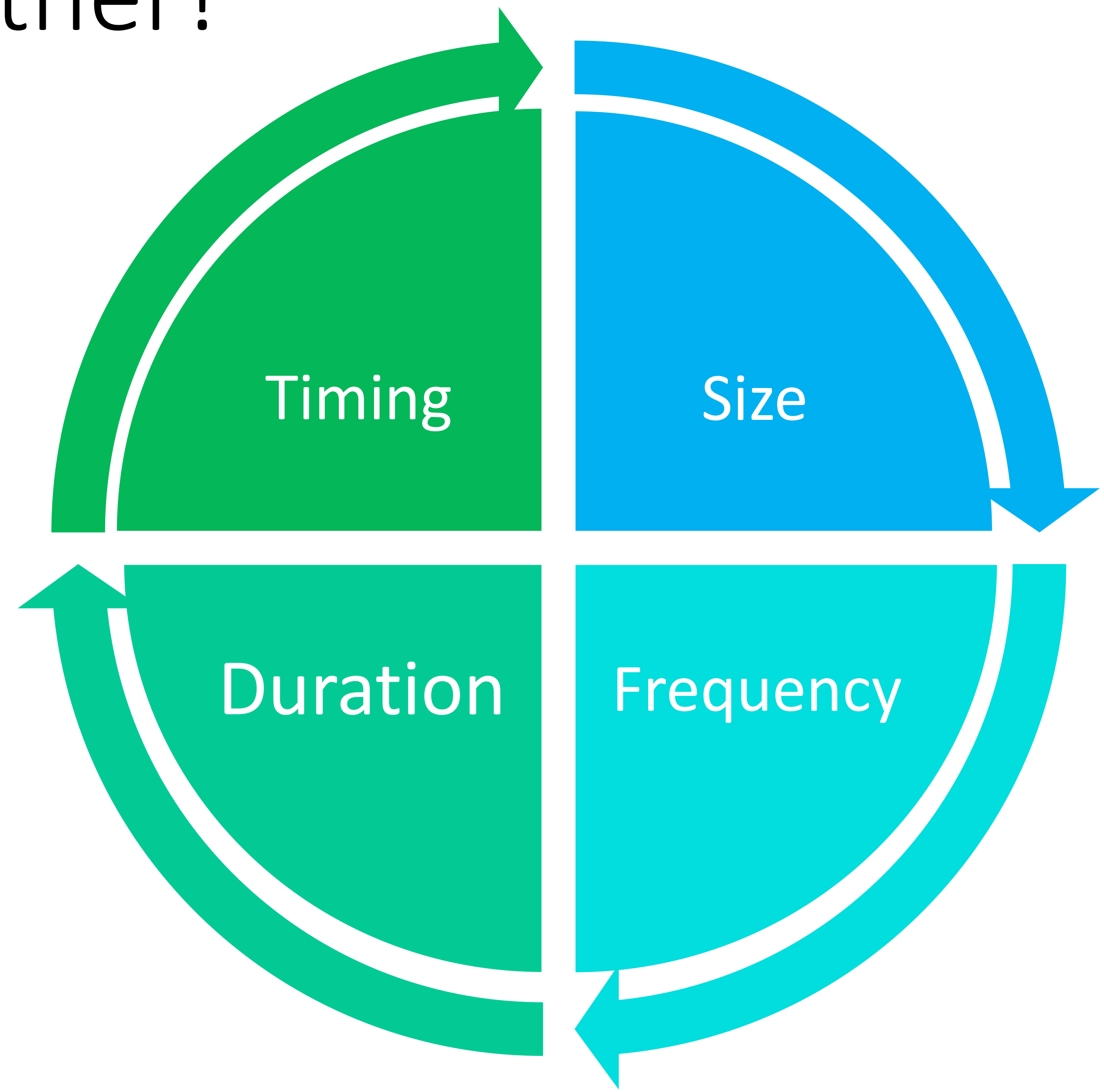
SURVEY OF RESOURCE ADEQUACY METRICS AND CRITERIA AROUND THE WORLD

	Metric	Criterion
North America - NERC Regions[10]		
NPCC – All 5 Areas[11]	LOLE	0.1 days/year
MISO	LOLE	0.1 days/year
MRO - Manitoba Hydro	LOLE/LOLH/EUE	0.1 days/year[12]
MRO – SaskPower	EUE	--
PJM	LOLE	0.1 days/year
SERC – All 4 Areas	LOLE	0.1 days/year
SPP	LOLE	0.1 days/year
TRE-ERCOP	LOLE	0.1 days/year
WECC – All 6 Areas	LOLP	0.02%[13]
Western Europe[14]		
Great Britain	LOLH	3 hours/year
France	LOLH	3 hours/year
Belgium	LOLH	3 hours/year
Netherlands	LOLH	4 hours/year
Ireland	LOLH	8 hours/year
Portugal	LOLH	8 hours/year
Australia[10]	Normalized EUE	0.002%

Our metrics need to go further!

Four Recommendations for Improved Use of Resource Adequacy Metrics

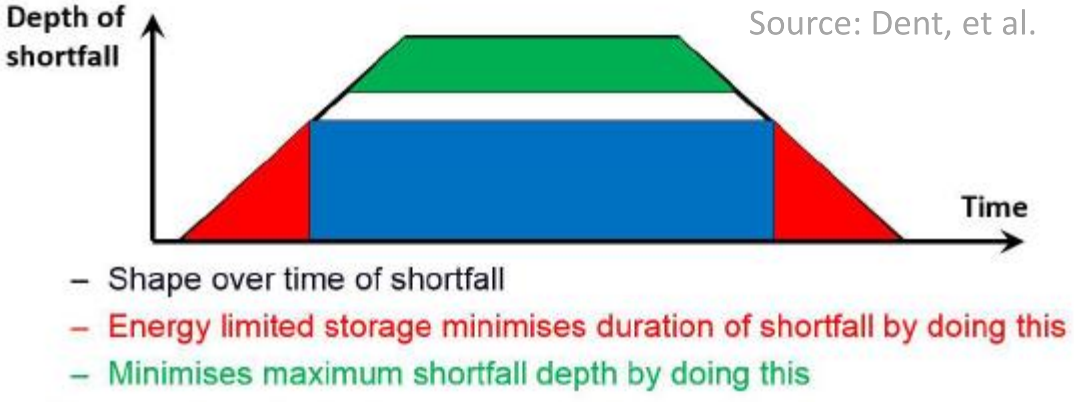
1. Place more emphasis on Expected Unserved Energy
2. Use a suite of reliability metrics, not just one
3. Move beyond expected values and consider tail events
4. Characterize size, frequency, duration, and timing of shortfall events



1 Place more emphasis on Expected Unserved Energy

- LOLE does not capture the magnitude of events when they occur
- Misses a potentially large measure of reliability as compared to a metric such as EUE.
- EUE captures the total quantity of energy that is expected to go unserved each year.
- While this metric is not perfect, it is likely the most robust metric in terms of measuring the true reliability of an electric system,
- Particularly useful in a system that is energy-constrained.
- But, EUE is not commonly used as a reliability metric in the industry today.

Source: E3, "Resource Adequacy in the Pacific Northwest"



Source: Dent, et al.

Benefits and Limitations of Using EUE

Benefits of EUE as an RA Metric
Measures size and duration of shortfall events
Evaluates risk across all hours of the year and not just on peak load periods
Places higher weight on large, disruptive, and catastrophic shortfall events
Easier to translate to an economic value by assigning a value of lost load (VoLL)
Better accounts for energy limitations of storage and load flexibility resources
Can provide more insights into timing of shortfall events (hour of day, day of week, month, season, etc.)

Limitations of EUE as an RA Metric
Does not explicitly capture the *frequency* of shortfalls
Requires more sophisticated statistical analysis and is more computationally intensive
Can overlook frequent, but small events that may be inconvenient to customers or politically damaging
Normalized EUE (nEUE) relative to system load can be difficult to interpret
Limited experience in setting EUE-based reliability criterion
More difficult to understand than a “1 day every 10 year” metric

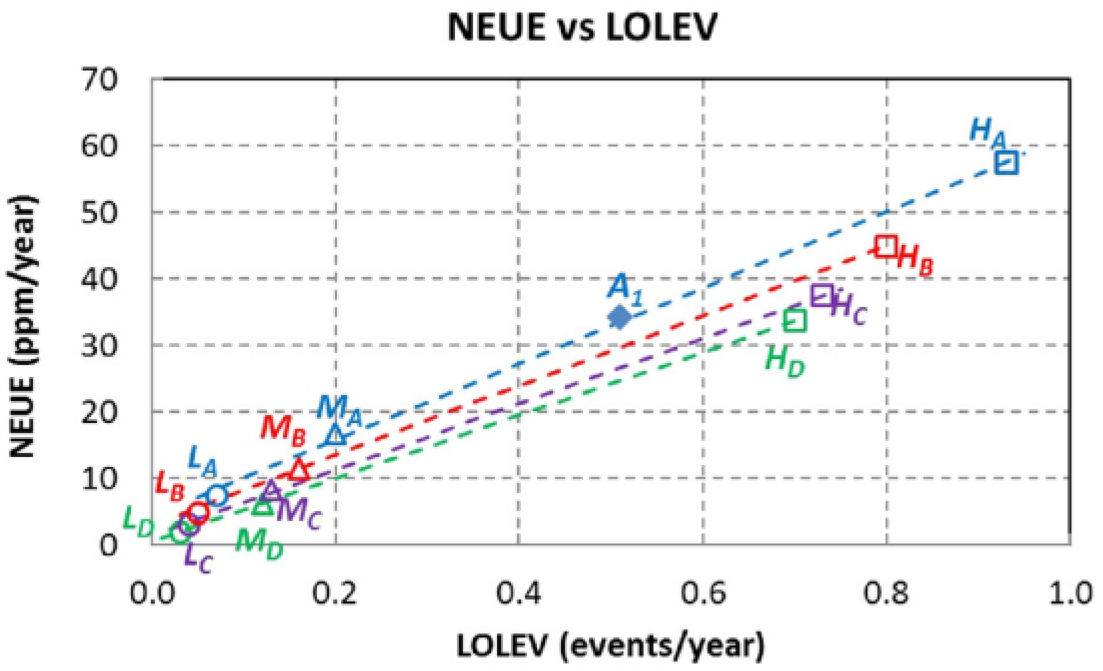
2

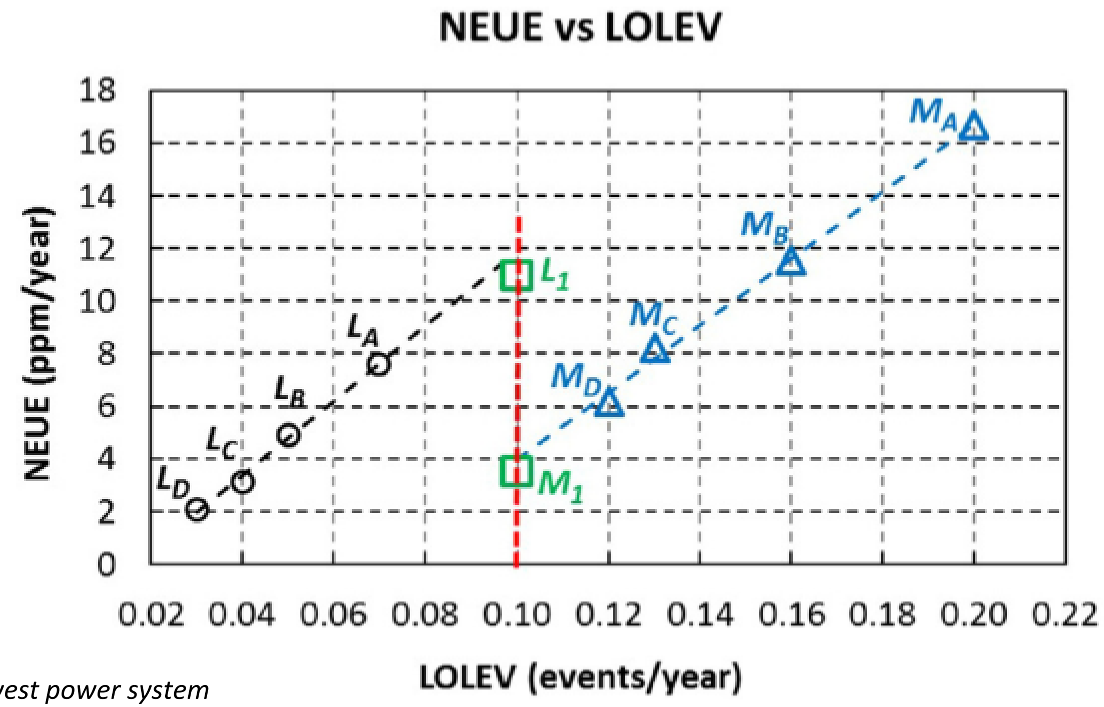
Use a suite of reliability metrics, not just one

Event Characteristic	Metric Affected	California Aug 2020	Texas Feb 2021	Difference
Number of Events	**LOLEv**	**2 events**	**1 event**	**-50%**
Number of Days	**LOLE**	**2 days**	**3 days**	**+50%**
Number of Hours	**LOLH**	**6 hours**	**71 hours**	**+1,083%**
Unserved Energy	**EUE**	**2,700 MWh**	**990,000 MWh**	**+36,567%**
Max Shortfall	**-**	**1,072 MW**	**20,000+ MW**	**+1,766%**

"It would be helpful when assessing resource adequacy, particularly of a system with a high percentage of intermittent energy-limited resource capacity, that the values for all three metrics, LOLH and EUE, as well as LOLE, be calculated. The Working Group therefore recommends that the NYISO and the NYSRC consider whether the 2021 IRM Study should calculate all three metrics and report them to the Executive Committee." -New York State Reliability Council

Understanding the relationships between EUE and LOLE





Source: Fazio & Hua, 2019, *Three probabilistic metrics for adequacy assessment of the Pacific Northwest power system*

"three adequacy metrics (LOLEV, NEUE and LOLH) can be used in a linear function to calculate with very good accuracy the other two metrics, but only for families of scenarios with fixed load or fixed resources

> … LOLEV, LOLH and NEUE, which measure shortfall frequency, duration and magnitude, form a good set of risk measures for a power supply,
>
> > … if the three metrics were to be used to determine power supply adequacy, then thresholds for all three metrics should be set independently"

3

Move beyond expected values

Average of ***all*** samples

Quantifying only samples with shortfall events

SCENARIO 1		Average	Average if…	25th percentile	Median	75th percentile	95th percentile	Max
LOLE	Days per year	0.10	1.38	1	1	2	2	3
LOLH	Hours per year	0.15	2.07	1	1	2	5	11
EUE	MWh per year	25	342	73	228	391	912	2,348

Same LOLE expected value

Very different extreme events

SCENARIO 2		Average	Average if…	25th percentile	Median	75th percentile	95th percentile	Max
LOLE	Days per year	0.10	1.31	1	1	1	3	6
LOLH	Hours per year	0.39	5.28	2	4	5	14	34
EUE	MWh per year	154	2088	405	918	2,249	6,792	16,563

Belgium's Dual RA Criterion

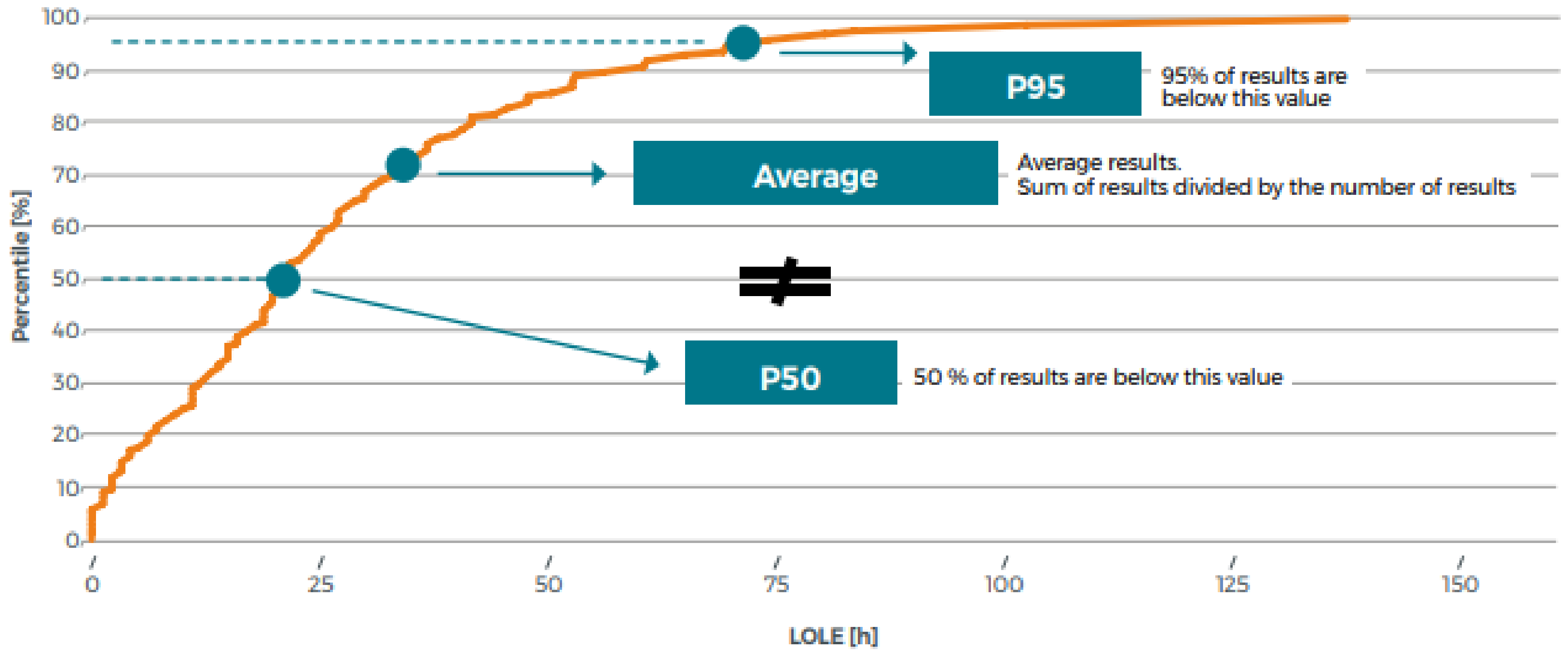
- There is precedent for using a dual RA criterion
- Belgium uses an *average* LOLH and a P95 *tail-end* LOLH

- ***LOLH:*** *A statistical calculation used as a basis for determining the anticipated number of hours during which, even taking into account inter-connectors, the generation resources available to the Belgian electricity grid will be unable to cover the load for a statistically normal year. (art.2, 52° Electricity Law – own translation)*
- ***LOLH95:*** *A statistical calculation used as a basis for determining the anticipated number of hours during which, even taking into account inter-connectors, the generation resources available to the Belgian electricity grid will be unable to cover the load for a statistically abnormal year. (art.2, 53° Electricity Law – own translation)*

ADEQUACY CRITERIA [FIGURE 1-1]

LOLH < 3 hours
LOLH95 < 20 hours

EXAMPLE OF A CUMULATIVE DISTRIBUTION FUNCTION OF LOLE [FIGURE 6-1]



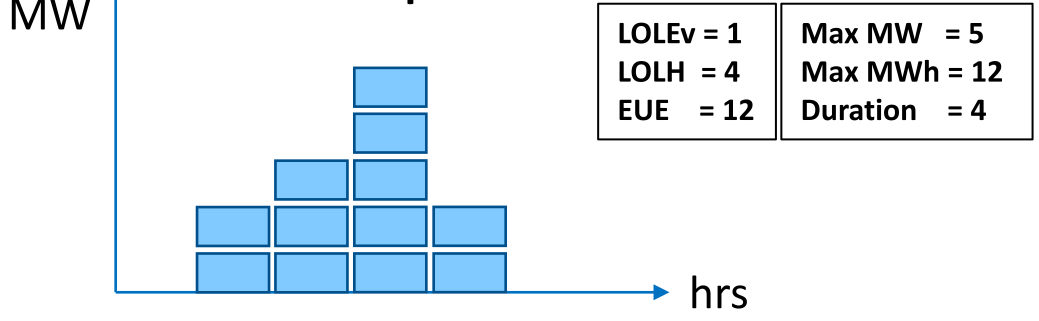
Source: Elia, Adequacy and flexibility study for Belgium 2020 - 2030

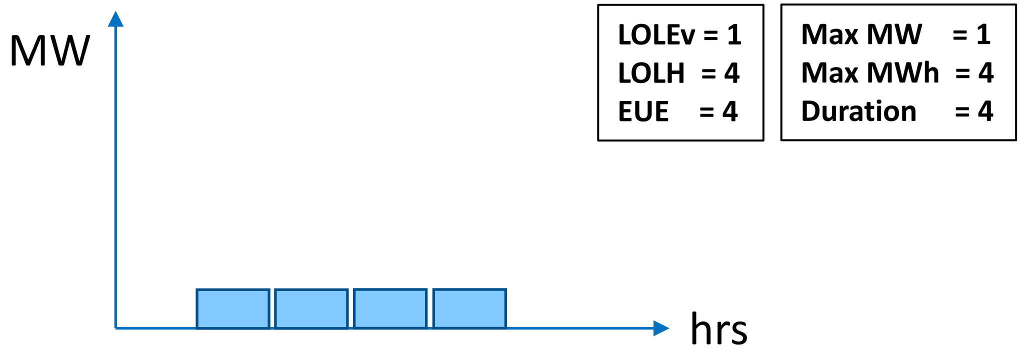
4

Quantifying size, frequency, duration, and timing of shortfalls is critical to finding the right resource solutions

Same LOLEv and LOLH, but very different events

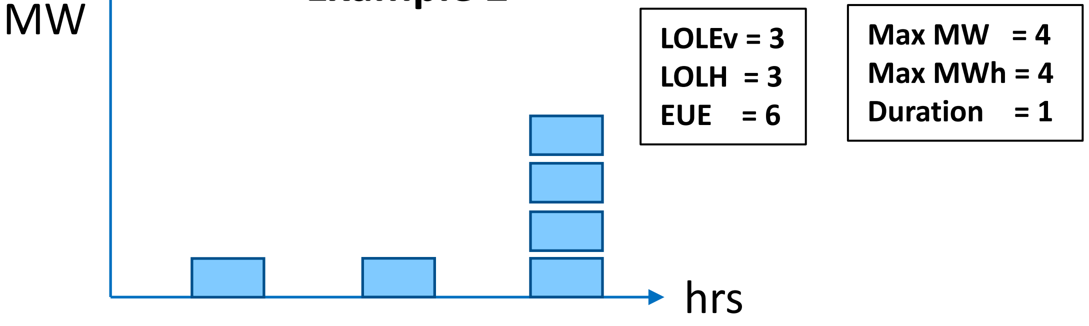
Example 1

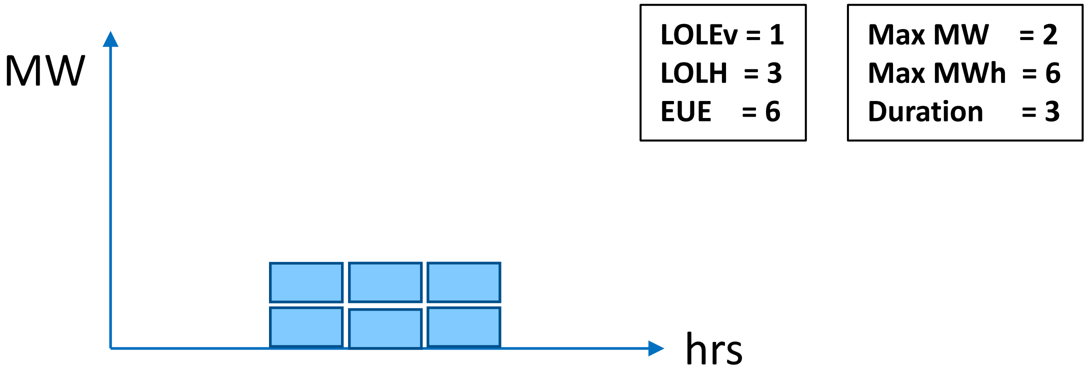




Same LOLH and EUE, but very different events

Example 2

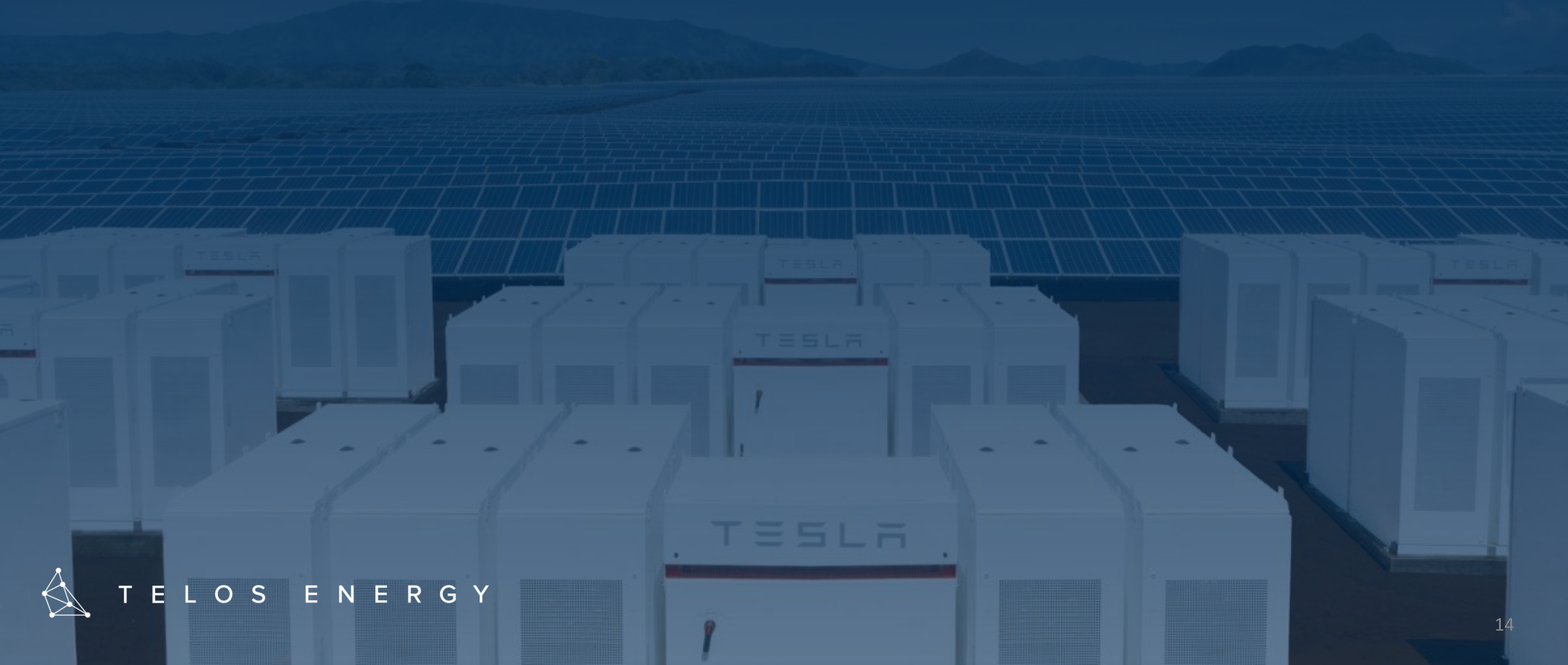




New & multiple metrics can better select and size appropriate mitigations (DR & BESS vs. thermal capacity)

Further Examples

Characterize size, frequency, duration, and timing of shortfall events



Demand response and storage can provide both power (MW) and energy (MWh) ... how much is needed of each?

Larger Power Shortfalls (MW) →

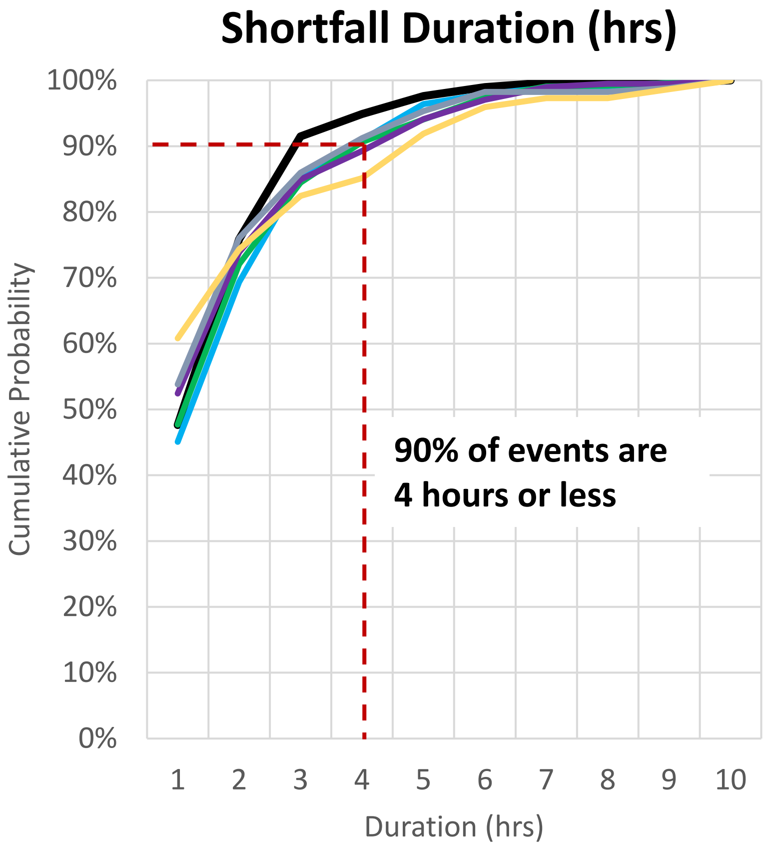
Larger Energy Shortfalls (MWh) ↓

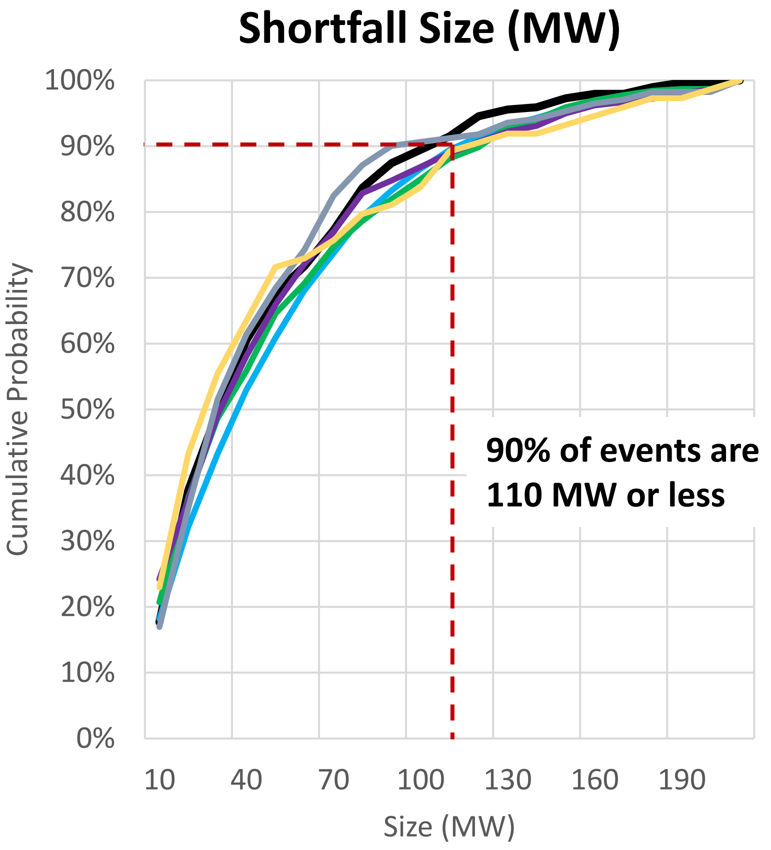
Energy (MWh)	Max Size (MW) 10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	>=200	Total
20	19.9%	14.4%	5.31%																		39.6%
40		0.70%	6.02%	6.11%	1.41%																14.2%
60			0.61%	2.34%	3.90%	1.60%	0.26%														8.7%
80			0.03%	0.58%	1.89%	2.18%	1.41%	0.16%													6.2%
100			0.03%	0.06%	0.64%	1.63%	1.66%	0.90%	0.06%	0.13%	0.06%										5.2%
120					0.06%	0.42%	1.12%	1.47%	0.67%	0.16%	0.10%	0.03%									4.0%
140							0.51%	1.02%	0.74%	0.35%	0.06%										2.7%
160						0.06%	0.32%	0.80%	0.42%	0.48%	0.19%	0.03%	0.03%								2.3%
180					0.03%		0.10%	0.35%	0.38%	0.42%	0.32%	0.06%	0.06%								1.7%
200							0.10%	0.29%	0.42%	0.51%	0.42%	0.32%	0.06%	0.03%	0.03%						2.2%
220						0.03%		0.06%	0.42%	0.16%	0.35%	0.26%	0.10%	0.03%							1.4%
240								0.06%	0.10%	0.16%	0.16%	0.29%	0.19%								1.0%
260								0.06%	0.03%	0.19%	0.35%	0.16%	0.29%	0.10%	0.19%		0.03%				1.4%
280							0.03%	0.03%	0.03%	0.03%	0.19%	0.19%	0.22%	0.10%	0.19%		0.03%				1.1%
300								0.03%		0.03%	0.16%	0.13%	0.13%	0.10%	0.03%						0.6%
320										0.10%	0.06%	0.06%	0.22%	0.10%	0.16%			0.03%			0.7%
340											0.03%	0.03%	0.16%	0.06%	0.16%	0.03%					0.5%
360											0.03%	0.10%	0.19%	0.06%	0.29%	0.03%	0.06%				0.8%
380												0.06%	0.03%	0.06%	0.13%	0.13%	0.16%				0.6%
400												0.06%	0.03%	0.16%		0.10%	0.06%	0.06%			0.5%
>400											0.16%	0.10%	0.22%	0.16%	0.35%	0.74%	0.32%	0.51%	0.42%	1.60%	4.6%
Total	19.9%	15.1%	12.0%	9.1%	7.9%	5.9%	5.5%	5.2%	3.3%	2.7%	2.7%	1.9%	2.0%	1.0%	1.5%	1.0%	0.7%	0.6%	0.4%	1.6%	100%

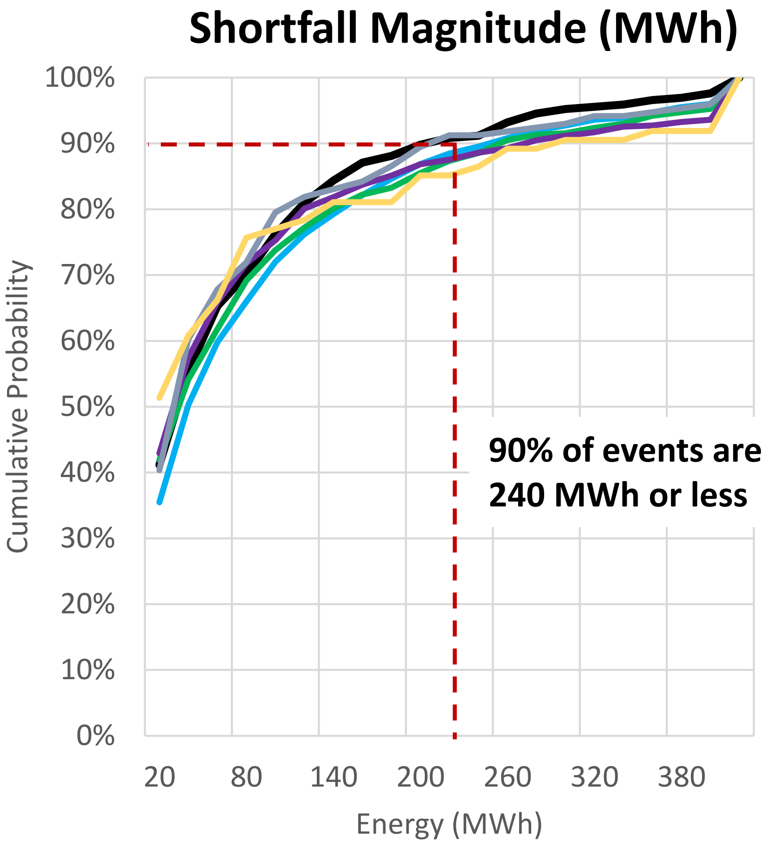
70% of events covered by 60 MW 2HR resource

85% of events covered by 100 MW 2HR resource

Evaluating cumulative distribution functions







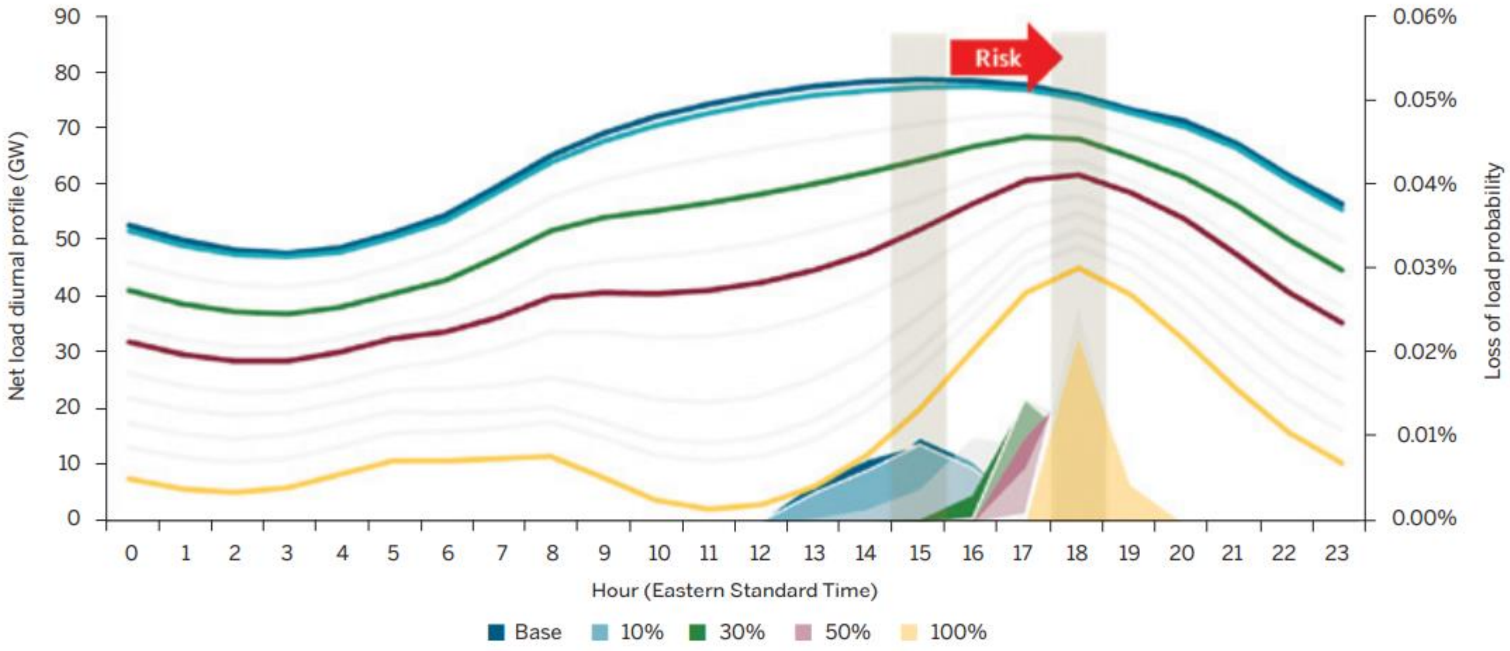
70% of events covered by 60 MW 2HR resource

85% of events covered by 100 MW 2HR resource

Histograms of size, frequency and duration

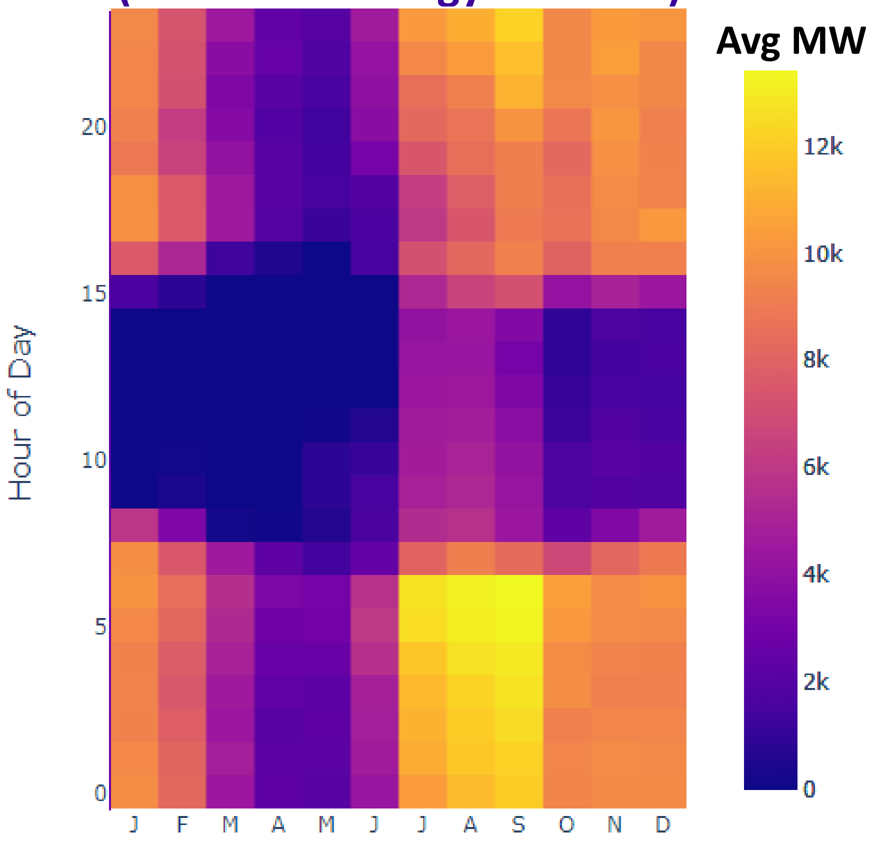
Characterizing timing of shortfall events

- Reliability risk is shifting
- Peak risk is no longer aligned with peak load
- Resources now come in all 'shapes and sizes'



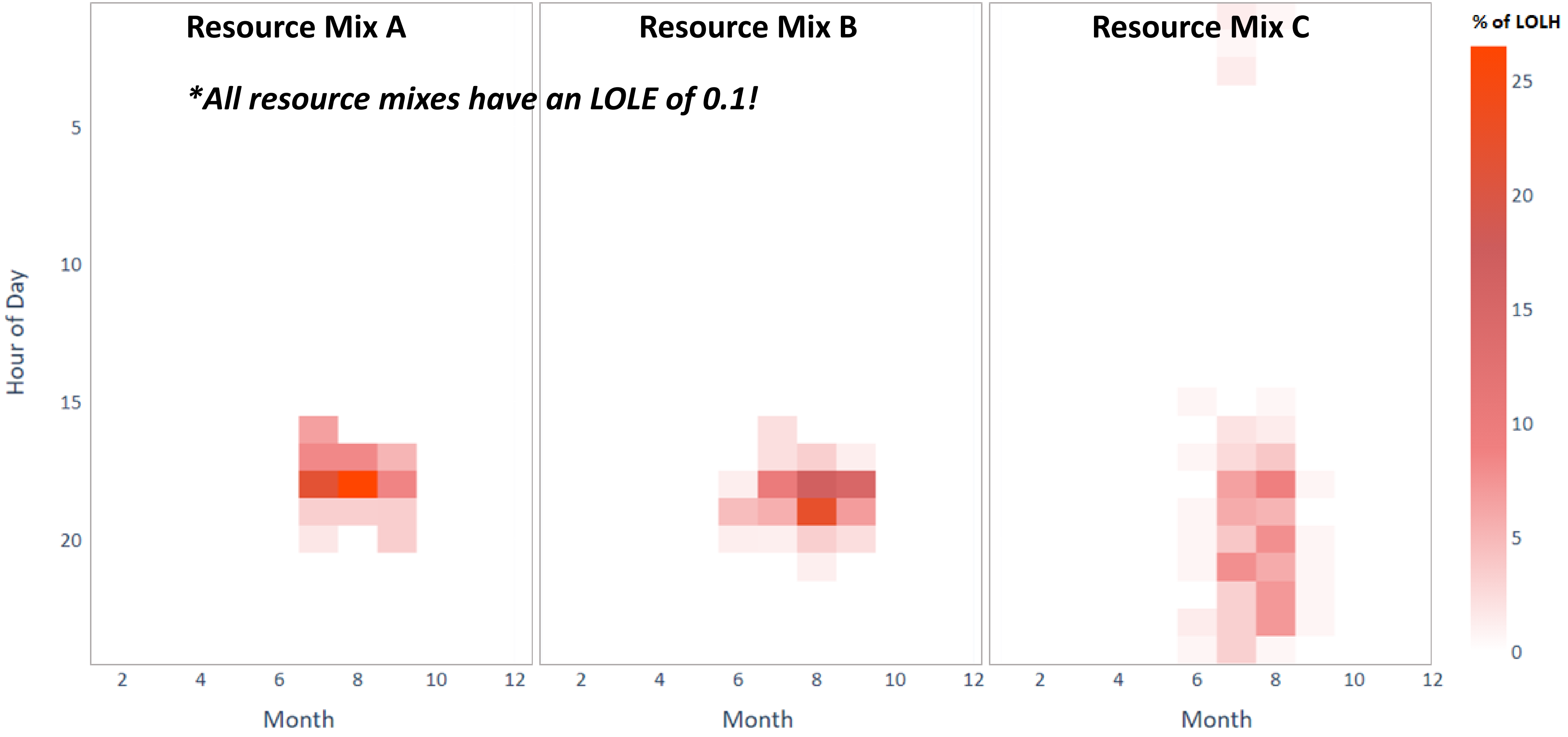
Source: MISO Renewable Integration Impact Assessment

California NG + Economic Imports (85% Clean Energy Portfolio)



Source: GridLab, Telos Energy – California Pathways to 100% Clean Energy, forthcoming

Seasonal and Time of Day Risk is Uneven, useful information for identifying mitigations



Thank You!

Questions?

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Want to get involved in the ESIG Redefining Resource Adequacy Task Force? Reach Out!

Refresher on Existing RA Metrics

Metric	Description	Limitations
Loss of Load Expectation (LOLE) days/year	Counts the number of loss of load **days** across all the random samples simulated. The total number of days with a shortfall is then divided by the number of samples to give an average days per year with a shortfall.	Quantifies the frequency of shortfalls, but does not provide information of size, duration or timing.
Loss of Load Events (LOLEv) events/year	Counts the number of loss of load **events** each year. Where an event is characterized as consecutive hours of a shortfall. Where one day may have multiple events, or one event may span multiple days.	Evaluates shortfall events based on consecutive duration, but does not provide information of size, duration or timing.
Loss of Load Hours (LOLH) hours/year	Counts the number of loss of load **hours** across all of the random samples simulated. The total number of hours with a shortfall is then divided by the number of samples to give an average hours per year with a shortfall.	Provides some insight into duration when combined with LOLE (LOLH/LOLE = hours/day) but does not provide insight into size of events.
Loss of Load Probability (LOLP) % of Days	Calculates a **probability** of a shortfall loss of load event occurring, between 0 and 1, often calculated as the number of days with a shortfall, divided by the total number of days sampled.	Similar to LOLE.
Expected Unserved Energy (EUE) MWh/year	Calculated the average amount of unserved **energy**, in MWh, in a given year. Unserved energy can be calculated as either the number of operating reserves not provided, or involuntary curtailed load.	Quantifies the size (magnitude) of loss of load, but does not provide information on the frequency or duration of the events.
Normalized Expected Unserved Energy (NEUE) % of load/year	Provides the same information as expected unserved energy but reports shortfalls as a percentage of system load as opposed to MWh to provide a relative risk level across different systems or load years.	Similar to EUE.