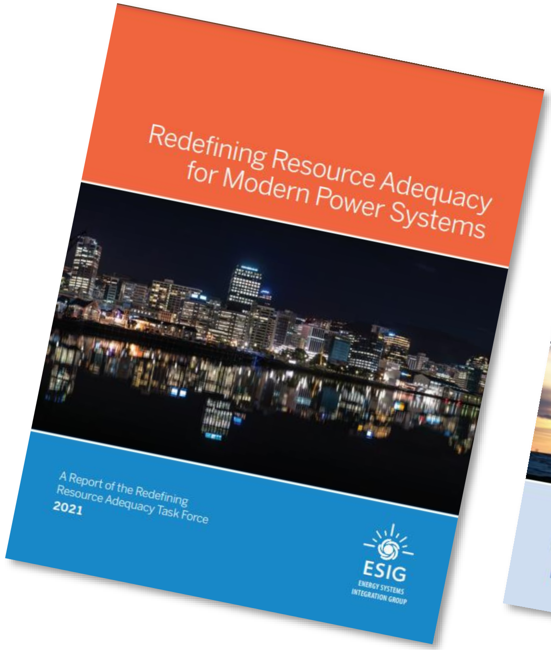
Resource Adequacy for Modern Power Systems

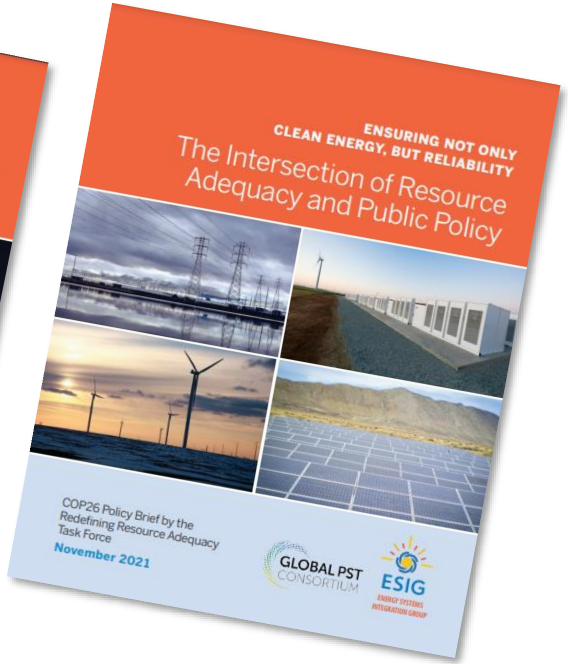
Weather Dependency & Extreme Weather Scenarios

NYSRC Extreme Weather Working Group
December 15, 2022

TELOS ENERGY

Redefining Resource Adequacy Task Force





- **ESIG Whitepaper:** Redefining Resource Adequacy for Modern Power Systems
- **ESIG/GPST Policy Brief:** The Intersection of Resource Adequacy and Public Policy
- **ESIG Blog:** Five Principles of Resource Adequacy for Modern Power Systems
- **ESIG Webinar 2020:** Redefining Resource Adequacy for Modern Power Systems (part 1)
- **ESIG Webinar 2021:** Redefining Resource Adequacy for Modern Power Systems (part 2)
- Stenclik, et al., Beyond Expected Values Evolving Metrics for Resource Adequacy Assessment, CIGRE Session 2022

Coming soon! Redefining **capacity accreditation**

What can we learn from the California and Texas events?

- **Not all shortfalls are alike**… need to characterize size, frequency duration, and timing of events
- **Risk is shifting**… periods of concern longer occur during gross-peak load, need to look across an entire year of operation

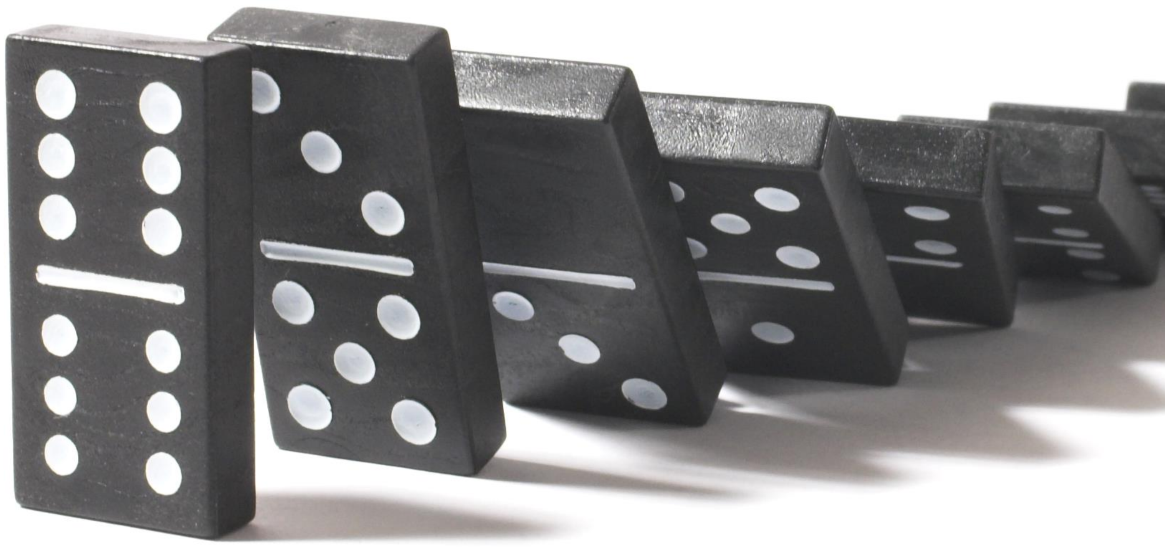
- **Weather** is the single most important driver for resource adequacy…
  - Cross-disciplinary power systems and meteorological expertise is necessary
  - We need a North-American Weather Dataset for correlated wind, solar, and load
  - Climate trends should be considered
  - Correlated events are the issue!

- **Resource sharing** is critical, transmission is a capacity resource

CHRONOLOGY + CORRELATION

- ✓ Variable Renewables
- ✓ Energy Storage
- ✓ Load Flexibility
- ✓ Hybrid resources

- ✓ Weather
- ✓ Combined Outages
- ✓ Modular Technology
- ✓ Climate Trends



Six principles of resource adequacy for modern power systems

1. Chronological operations must be modeled across many weather years
2. Quantifying size, frequency, duration, and timing of capacity shortfalls is critical to finding the right resource solutions
3. Neighboring grids and transmission are a key part of the RA challenge
4. There is no such thing as perfect capacity.
5. Load participation fundamentally changes the resource adequacy construct.
6. Reliability criterion should not be arbitrary, but transparent and economic.

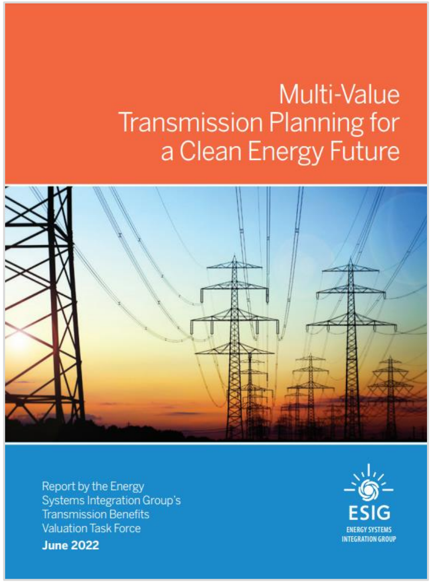
Best Practices for Modeling Extreme Weather

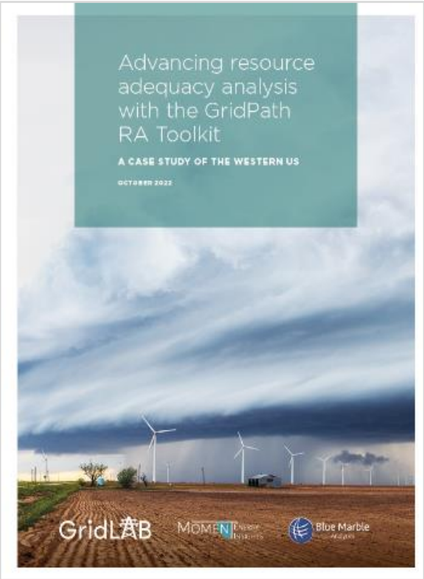
Do's	Don'ts
Consult a meteorologist Cross-disciplinary analysis is required	Go it alone. Power system engineers need to be cautious when bootstrapping datasets, especially for outlier events
Evaluate high-impact, low probability events for what-if analysis ("Black Swan" events)	Try to assign a probability or likelihood of the HILP, and incorporate it directly into the planning reserve margin
Use real weather data, based on actual meteorological conditions	Develop a "doomsday" scenario where worst-case contingencies occur simultaneously and arbitrarily
Consider weather, load, and system resource mix in neighboring balancing authorities	Assume your balancing area is an island, without interchange to neighboring systems (unless its an actual island)
Apply stress conditions to all resource types, including weather dependent outages and fuel limitations	Assume extreme weather only impacts renewables

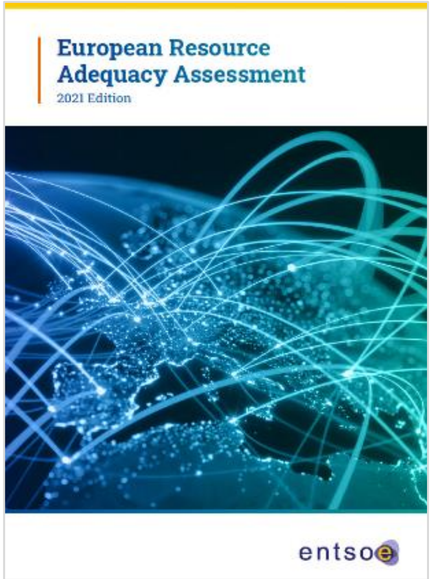
Others: incorporate transmission, bottoms-up load forecasting, etc.

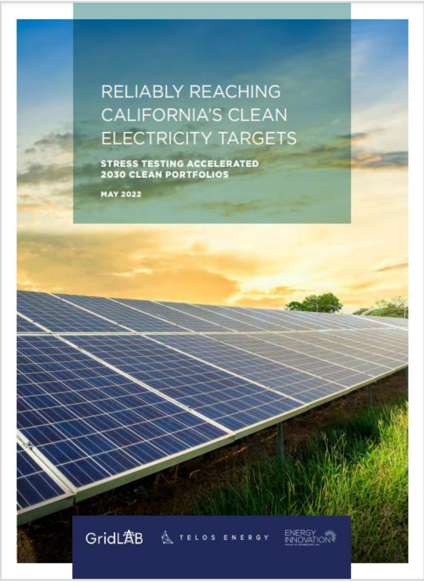
2022 Resource Adequacy

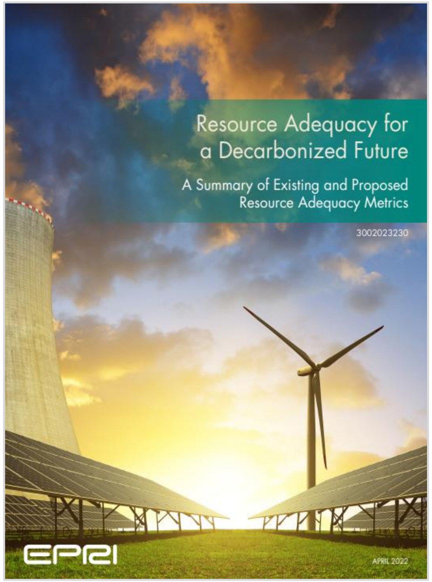
Case Study Review

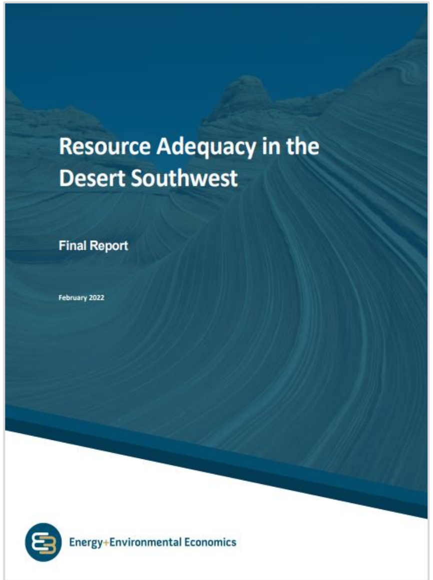


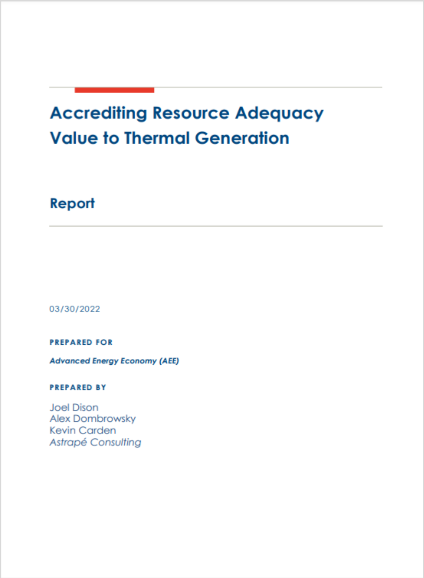












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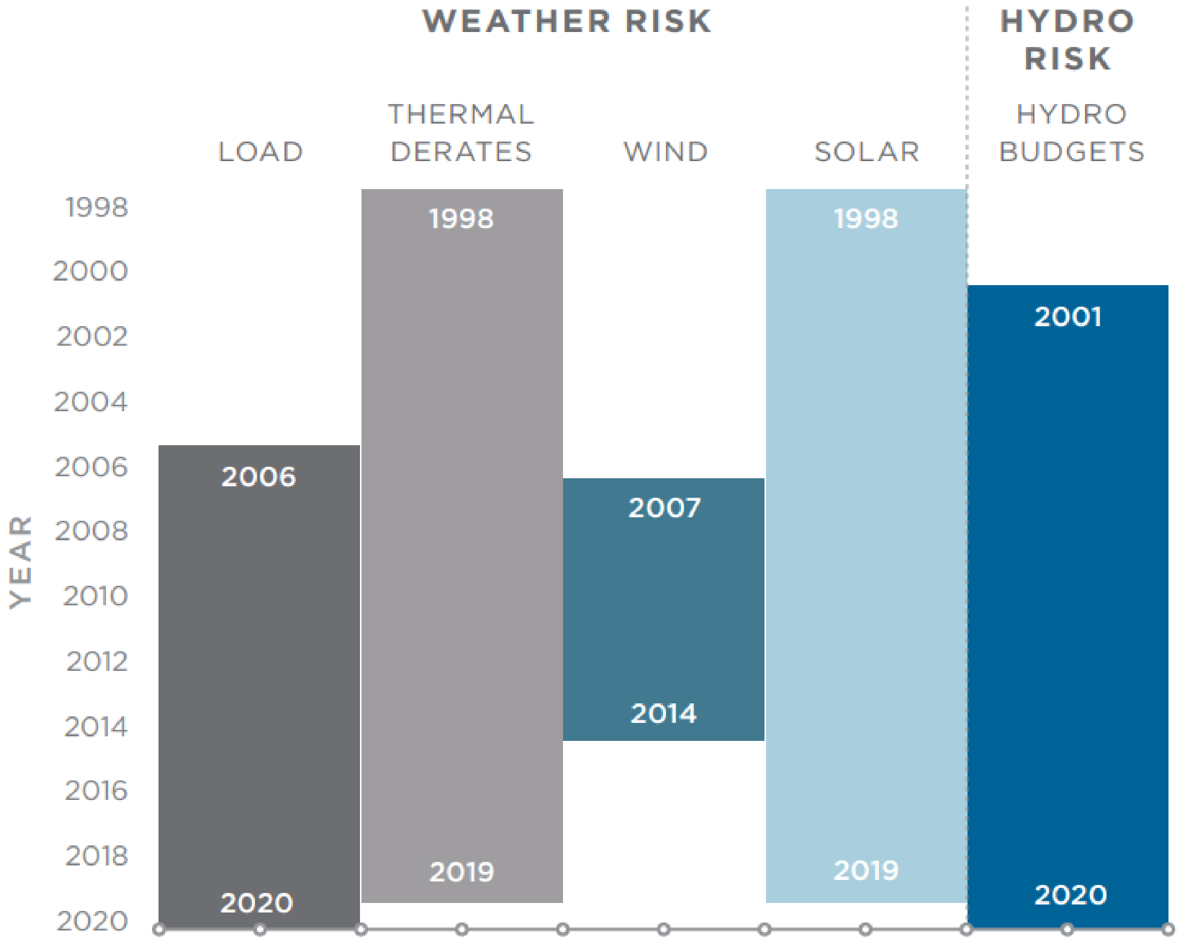
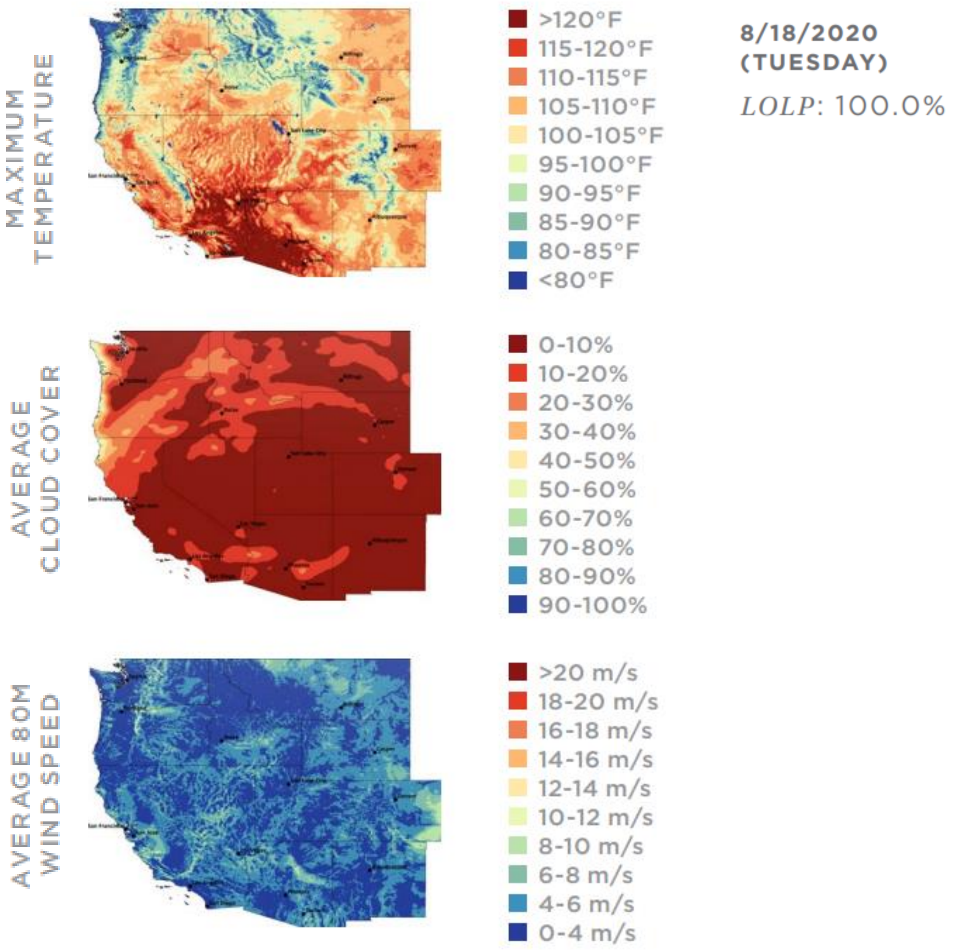
Resource transition is highlighting the importance of multi-year, correlated, interconnection-wide weather datasets

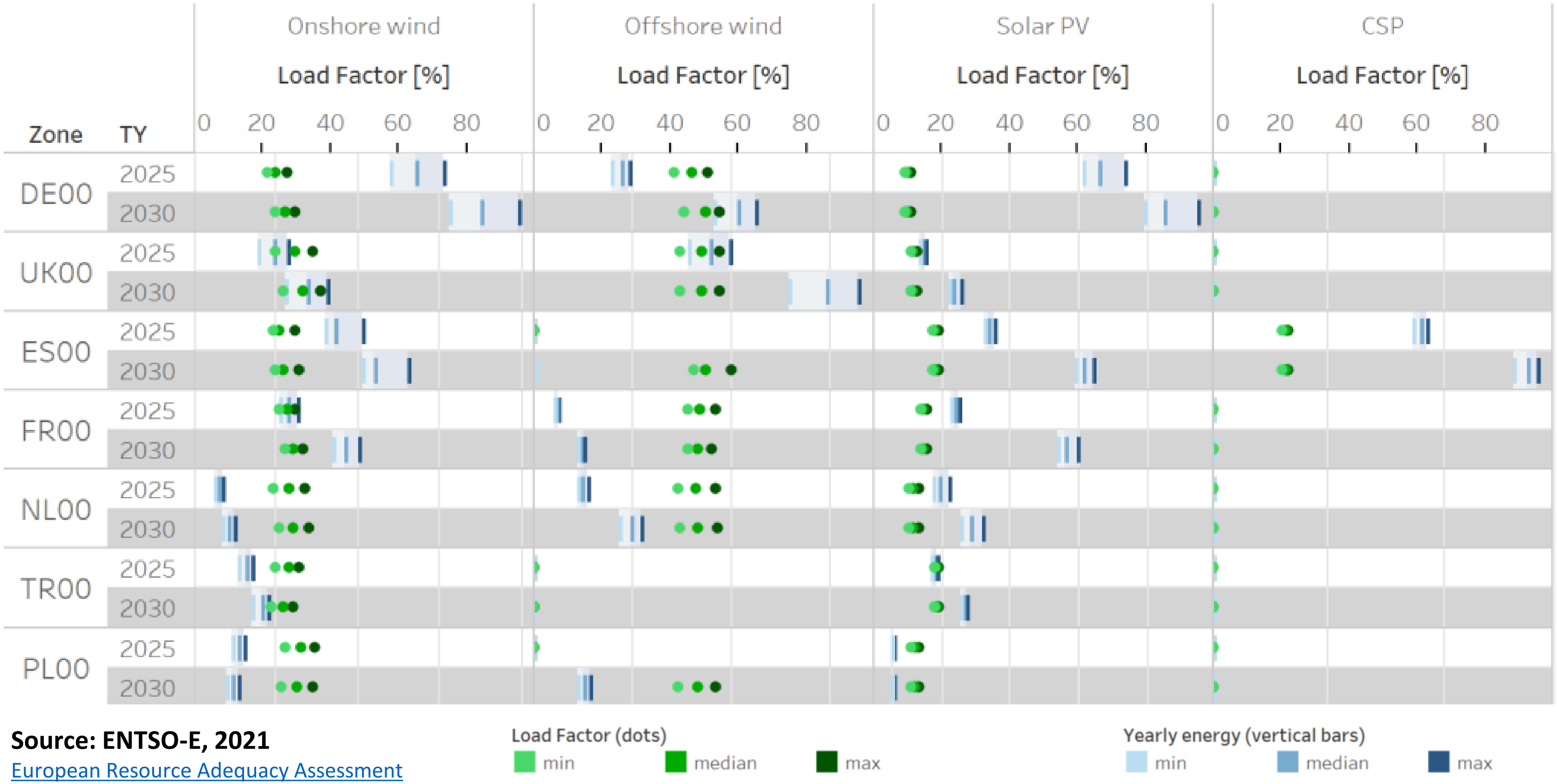


Source: GridLab, 2022,
[Advancing resource adequacy analysis with the GridPath RA Toolkit]



Best-practice in Europe… Pan-European climatological dataset across 35 weather years

Includes Climate Trends!



Source: ENTSO-E, 2021
[European Resource Adequacy Assessment]

1 analysis
covering
39 TOs
across
35 countries

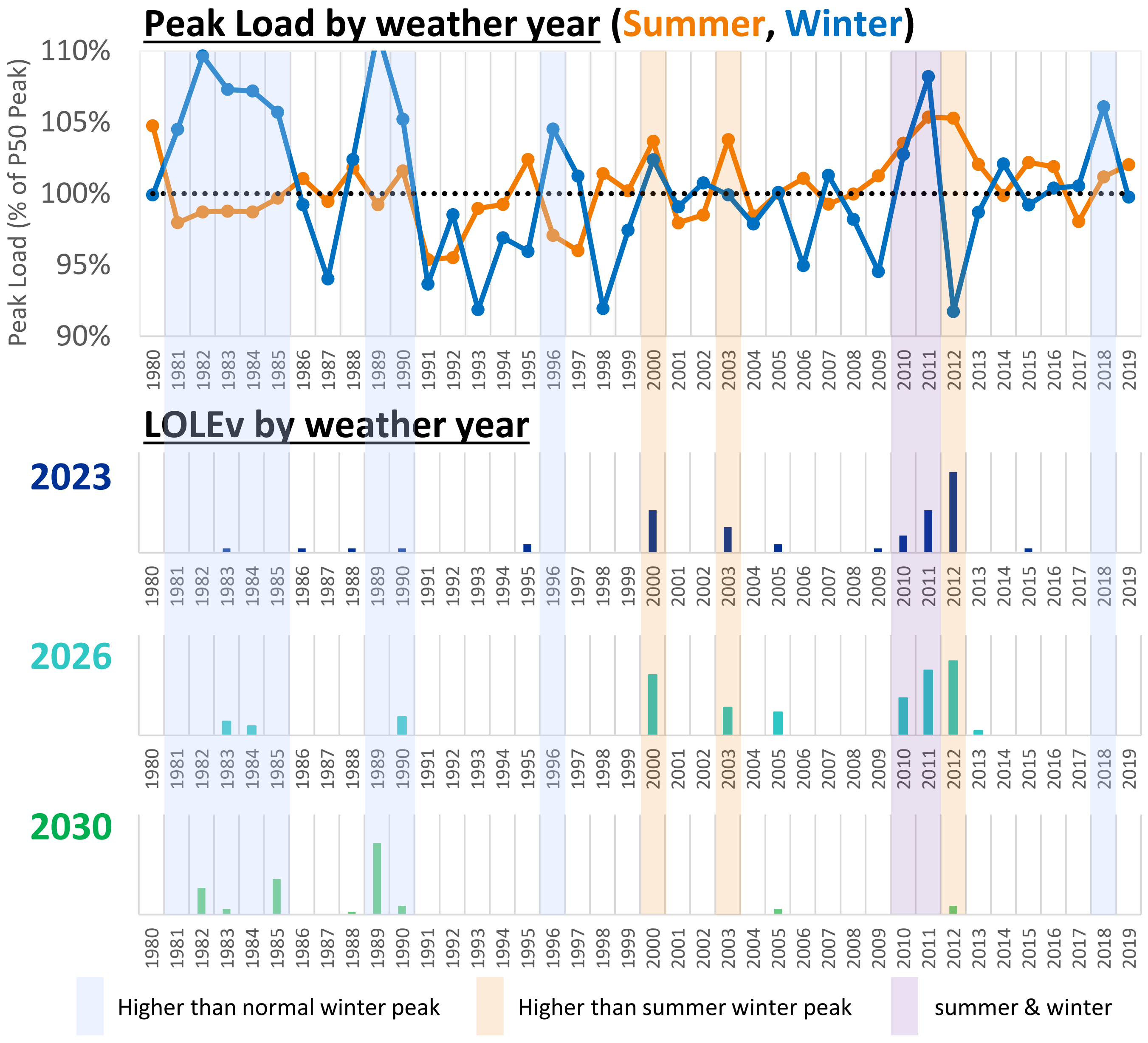
ESIG Task Force: new opportunity in North America – develop a consistent multi-weather year, continental dataset

ERCOT Case Study

Correlated weather impacts on renewable output and load response stresses the model in ways that expected profiles would not

- 40-year load dataset
- 40-year wind & solar dataset
  - Covers existing and potential future generators
  - Includes icing and cold weather impacts

High renewable system quantifies shifting risk to winter periods and different years of this historical record



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Source: EPRI, Telos Energy, *forthcoming*
Resource Adequacy for a Decarbonized Future

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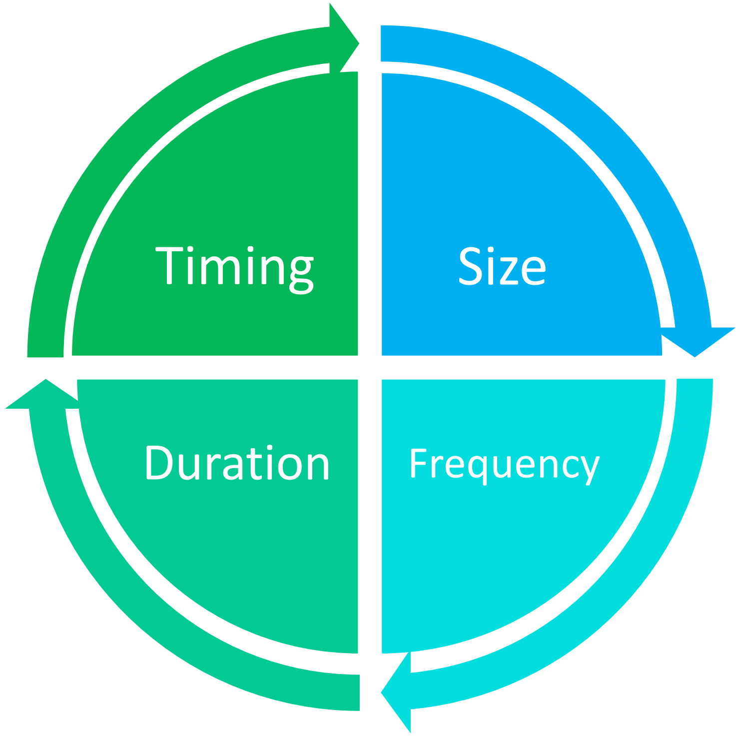
Quantifying **size**, **frequency**, **duration**, and **timing** of capacity shortfalls is critical to finding the right resource solutions



Our metrics need to go further!

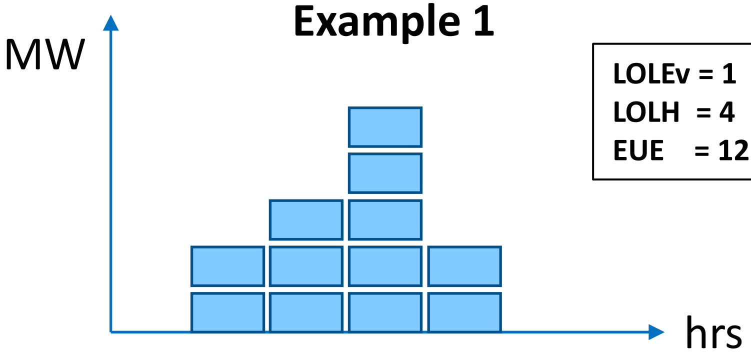
1. Place more emphasis on Expected Unserved Energy
2. Use a suite of reliability metrics, not just one
3. Move beyond expected values and consider tail events
4. Characterize size, frequency, duration, and timing of shortfall events

Event Characteristic	Metric Affected	California Aug 2020	Texas Feb 2021	Delta
Number of Days	LOLE	2 days	4 days	+200%
Number of Events	LOLEv	2 events	1 event	-50%
Number of Hours	LOLH	6 hours	71 hours	+1200%
Unserved Energy	EUE	2,700 MWh	990,000 MWh	+36,700%
Max Shortfall		1,072 MW	20,000+ MW	+1,766%

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

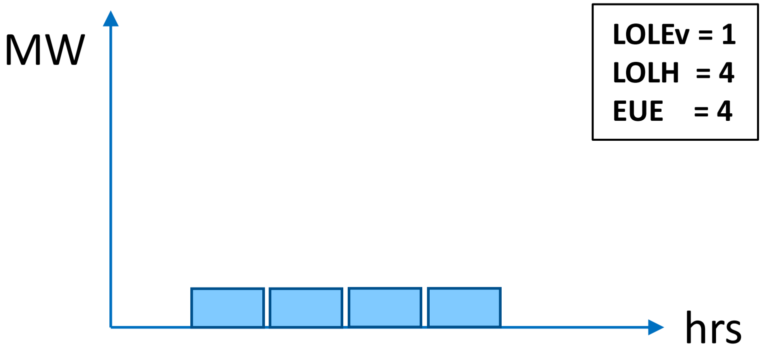
Same LOLEv and LOLH, but very different events

Example 1



LOLEv = 1
LOLH = 4
EUE = 12

Max MW = 5
Max MWh = 12
Duration = 4

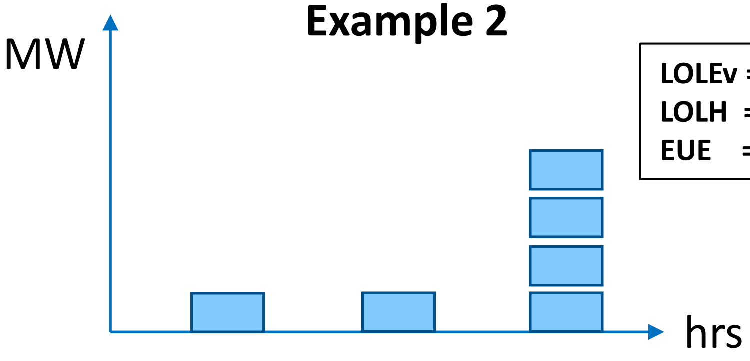


LOLEv = 1
LOLH = 4
EUE = 4

Max MW = 1
Max MWh = 4
Duration = 4

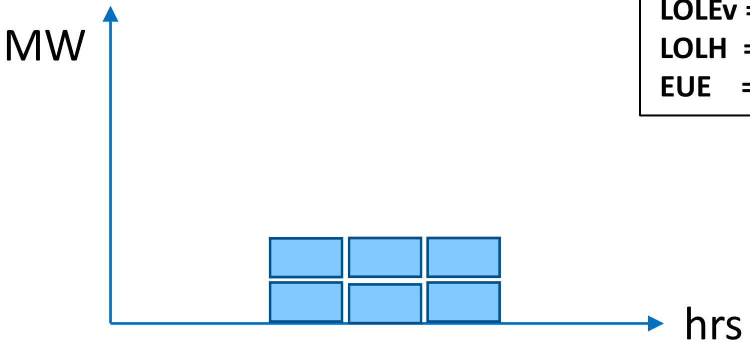
Same LOLH and EUE, but very different events

Example 2



LOLEv = 3
LOLH = 3
EUE = 6

Max MW = 4
Max MWh = 4
Duration = 1



LOLEv = 1
LOLH = 3
EUE = 6

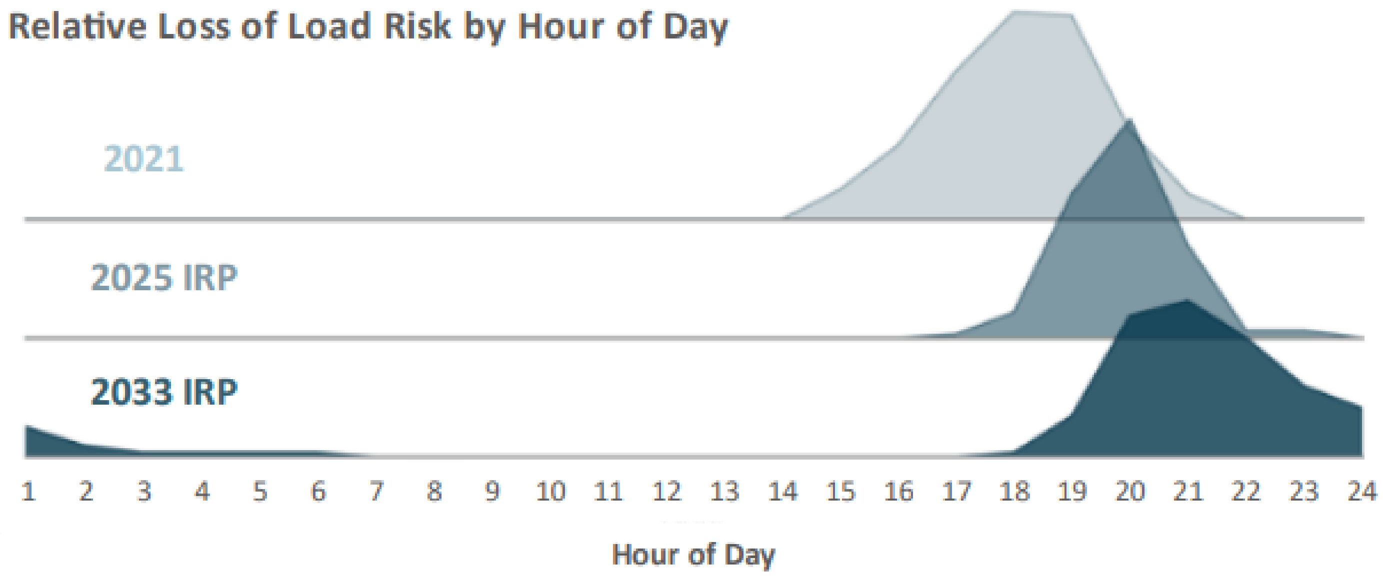
Max MW = 2
Max MWh = 6
Duration = 3

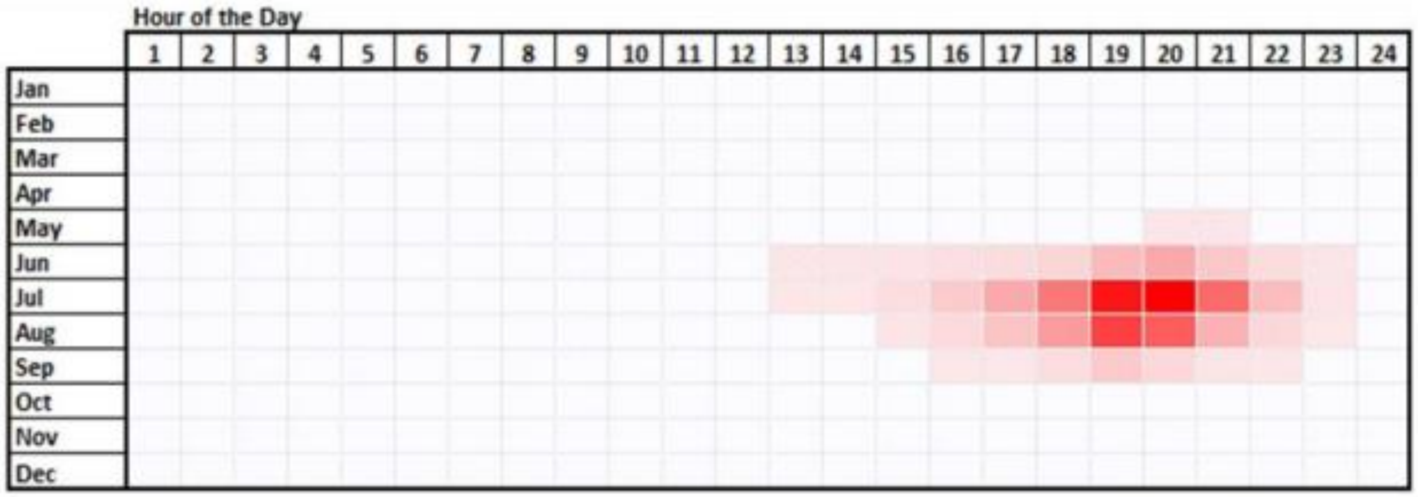
New & multiple metrics can better select and size appropriate mitigations (DR & BESS vs. thermal capacity)

When are events occurring?

As the resource mix changes, risk will shift diurnally and seasonally

In many parts of the U.S. this will be into the later evenings and eventually into the winter season

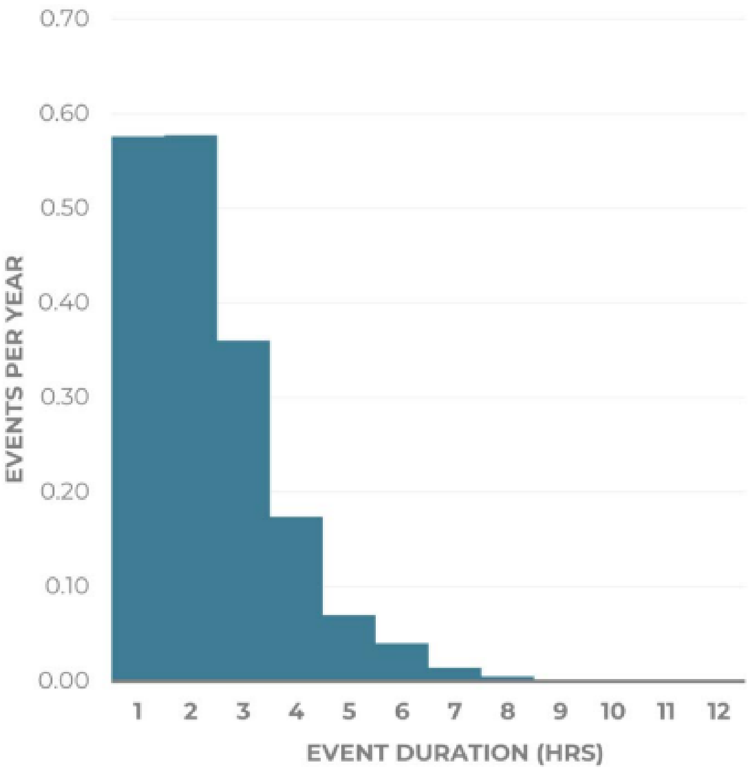




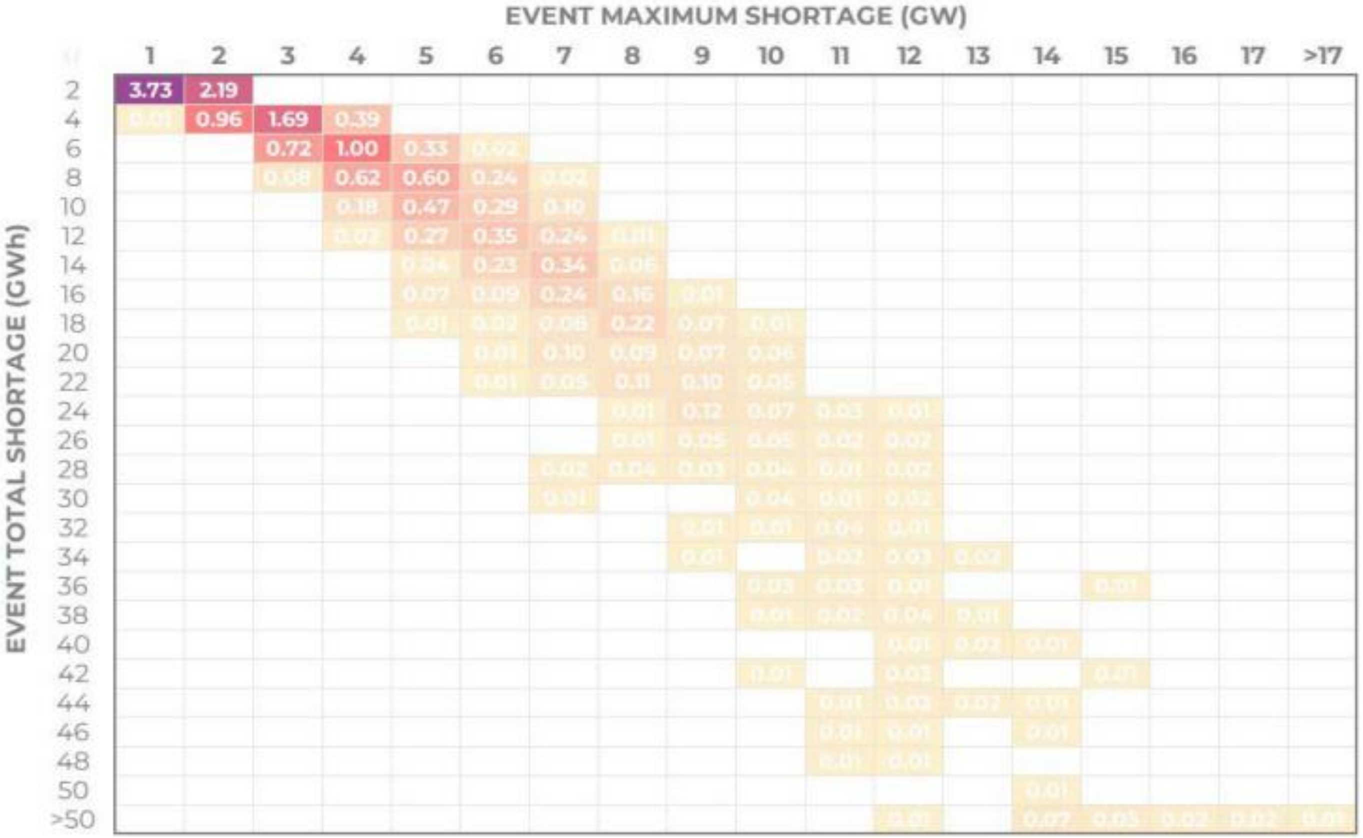
Source: E3, 2022,
[Resource Adequacy in the Desert Southwest]

Characterizing event size is necessary to properly size mitigations

EVENT DURATION DISTRIBUTION

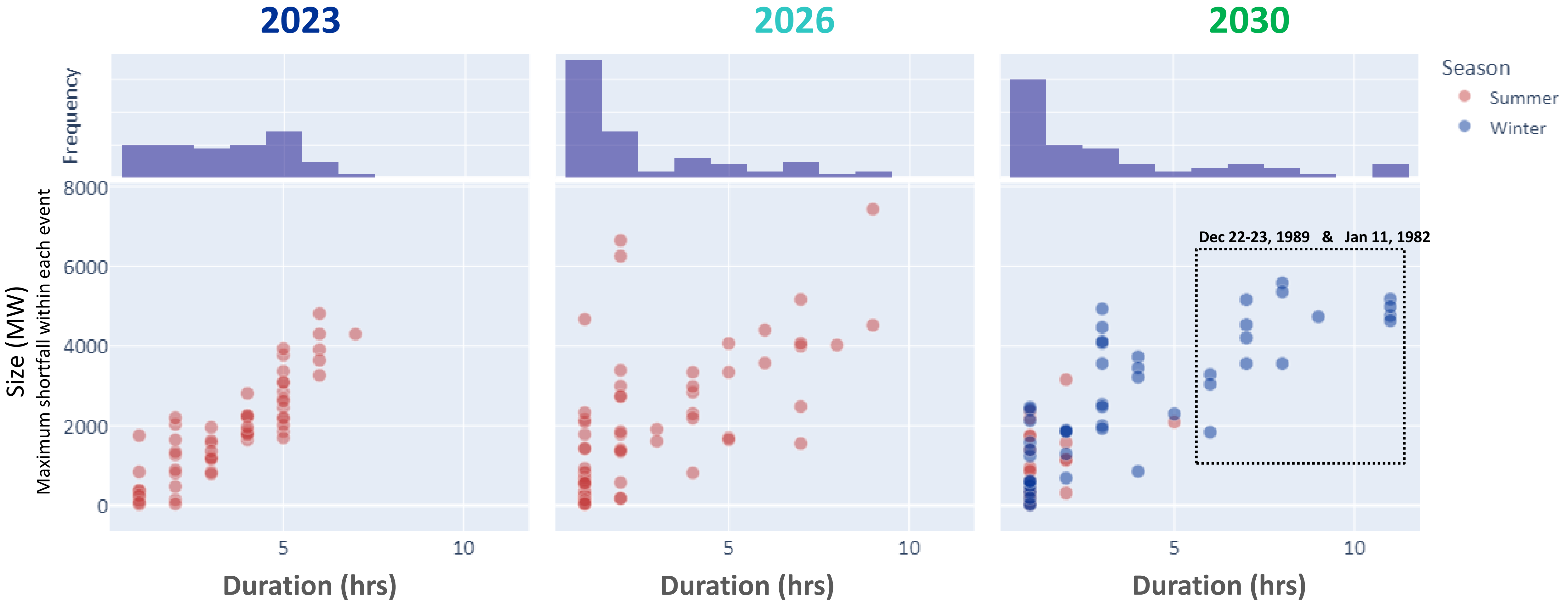


EXPECTED DAYS OF LOST LOAD IN 10 YEARS



Source: GridLab, 2022,
[Advancing resource adequacy analysis with the GridPath RA Toolkit]

Characterizing individual events for further insights help understand risks and potential mitigations



30% of events occur on June 25-26, Weather Year 2012

47% of events occur on Dec 22-23, Weather Year 1989 & Jan 11, Weather Year 1982

Source: EPRI, Telos Energy, *forthcoming*
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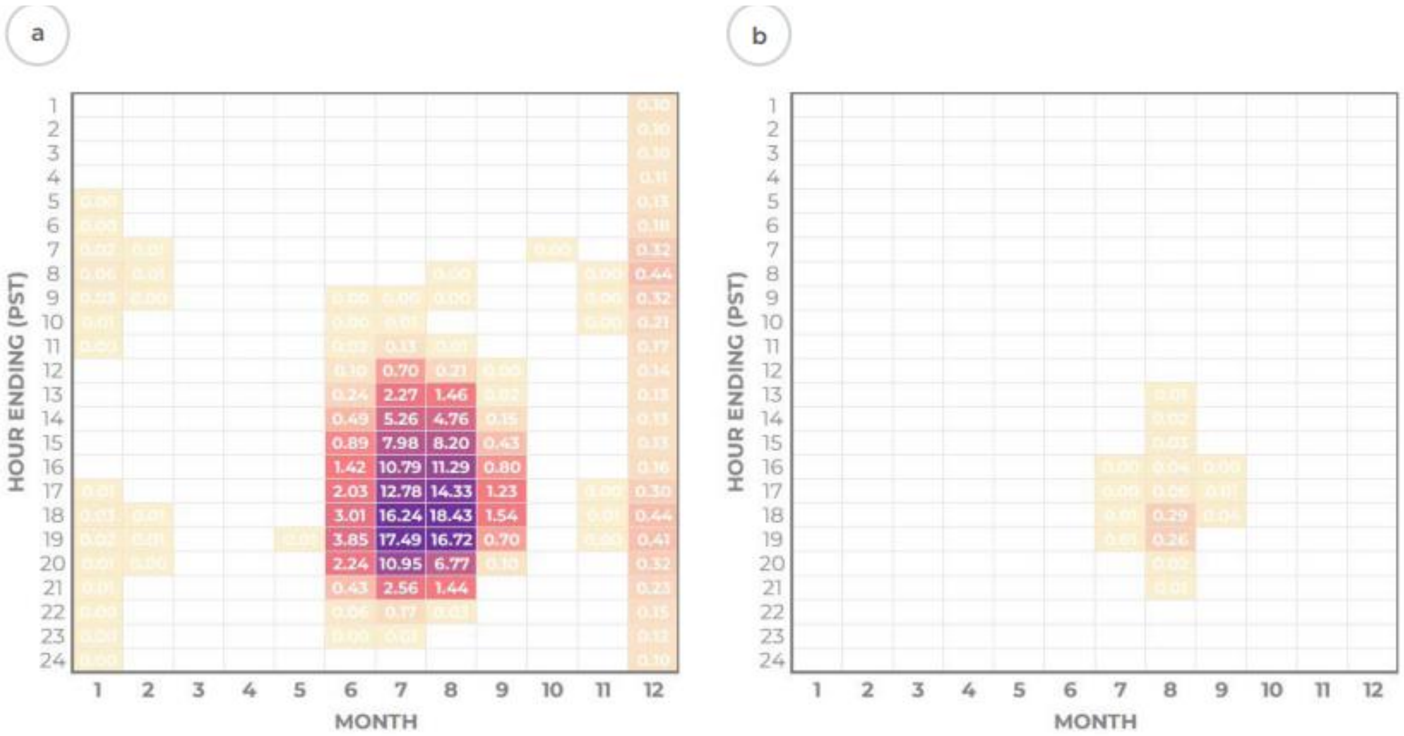
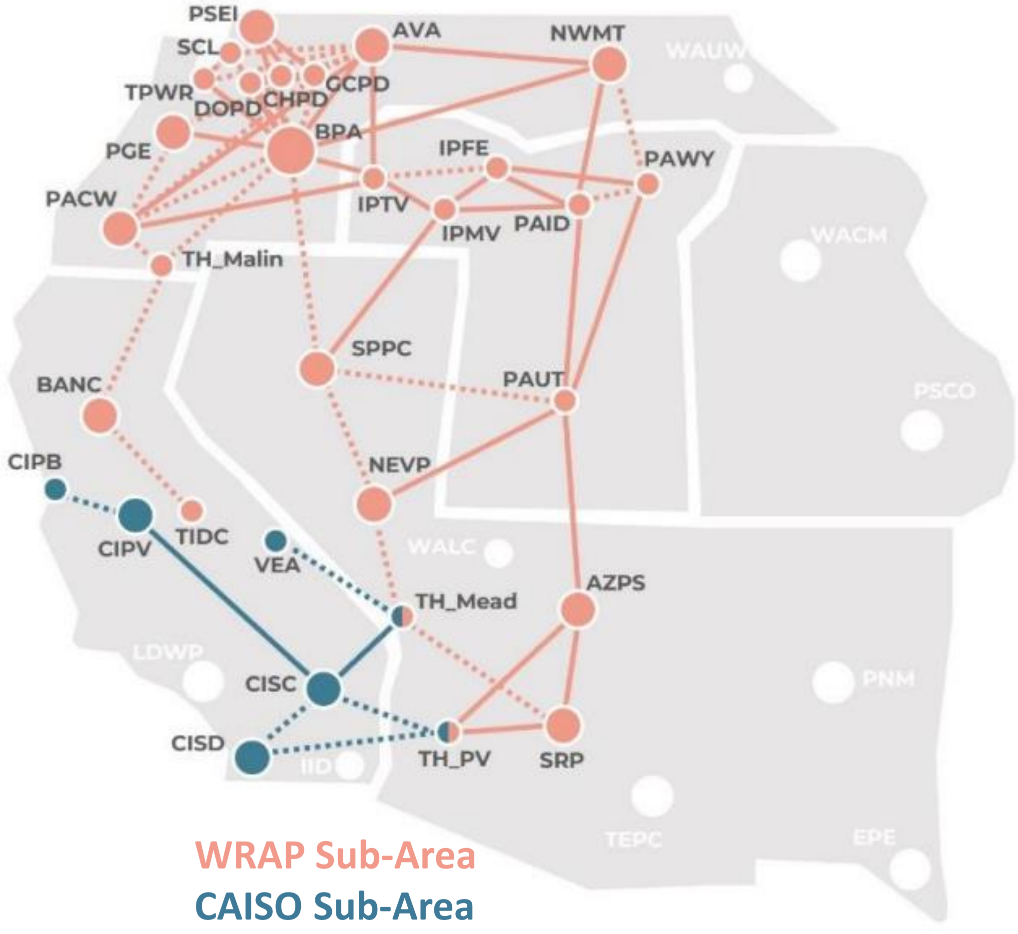
Interregional coordination and transmission can be a capacity resource, but only if we evaluate it

Loss of load hours per year for the WRAP subarea in the Less Coal Scenario when (a) the subarea is modeled as an island and (b) the subarea has access to imports.





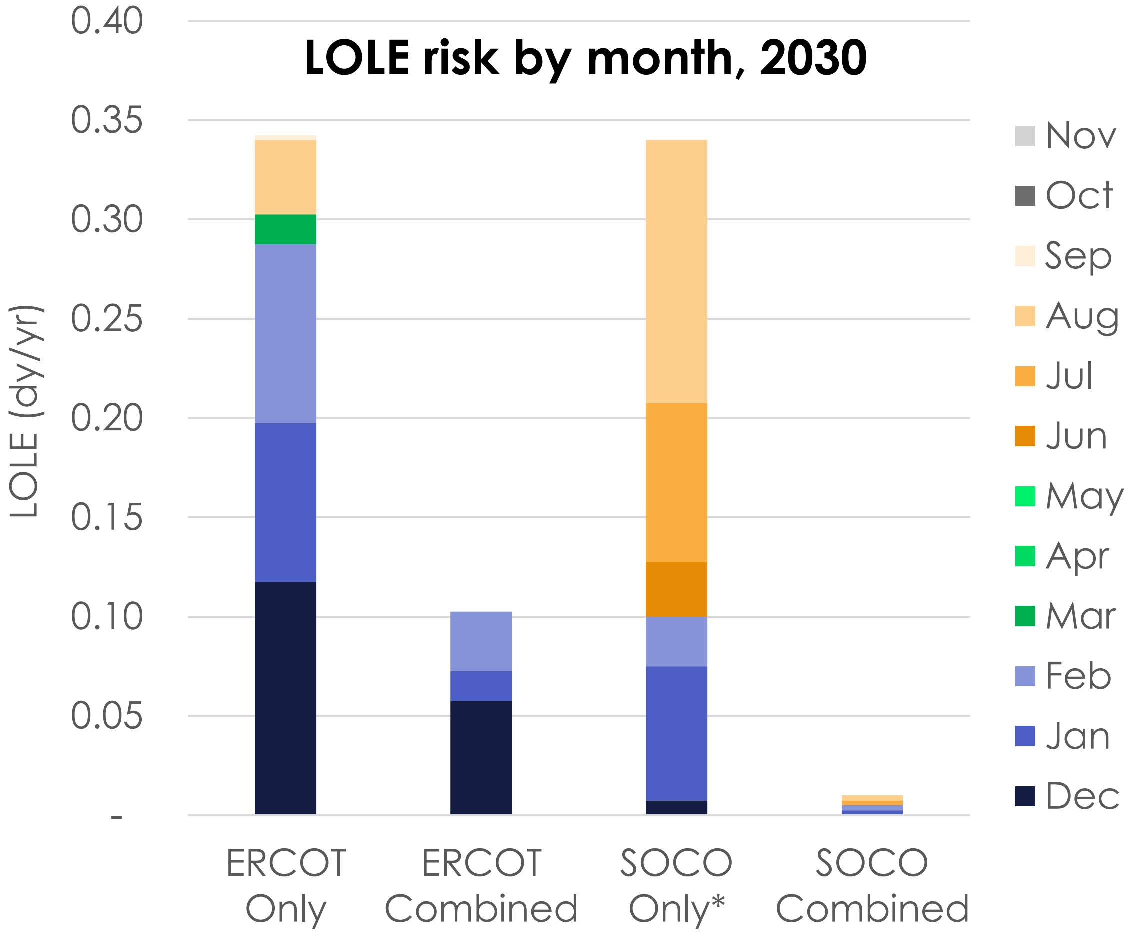
Source: GridLab, 2022,
[Advancing resource adequacy analysis with the GridPath RA Toolkit]

Evaluating capacity contributions of new transmission

- **With additional Southern retirements, the connected system sees RA benefits at both ends of the HVDC line *without adding any new resources***
- Interregional transmission accesses load diversity and renewable resource diversity
- Improves ERCOT resource adequacy and enables deferral of new gas capacity and additional coal retirements in southeastern US
- Intereregional transmission can have a

  200% Capacity Credit

  a 2 GW line can improve resource adequacy similar to 4 GW of new natural gas capacity [2 GW in ERCOT + 2 GW in Southern Company]



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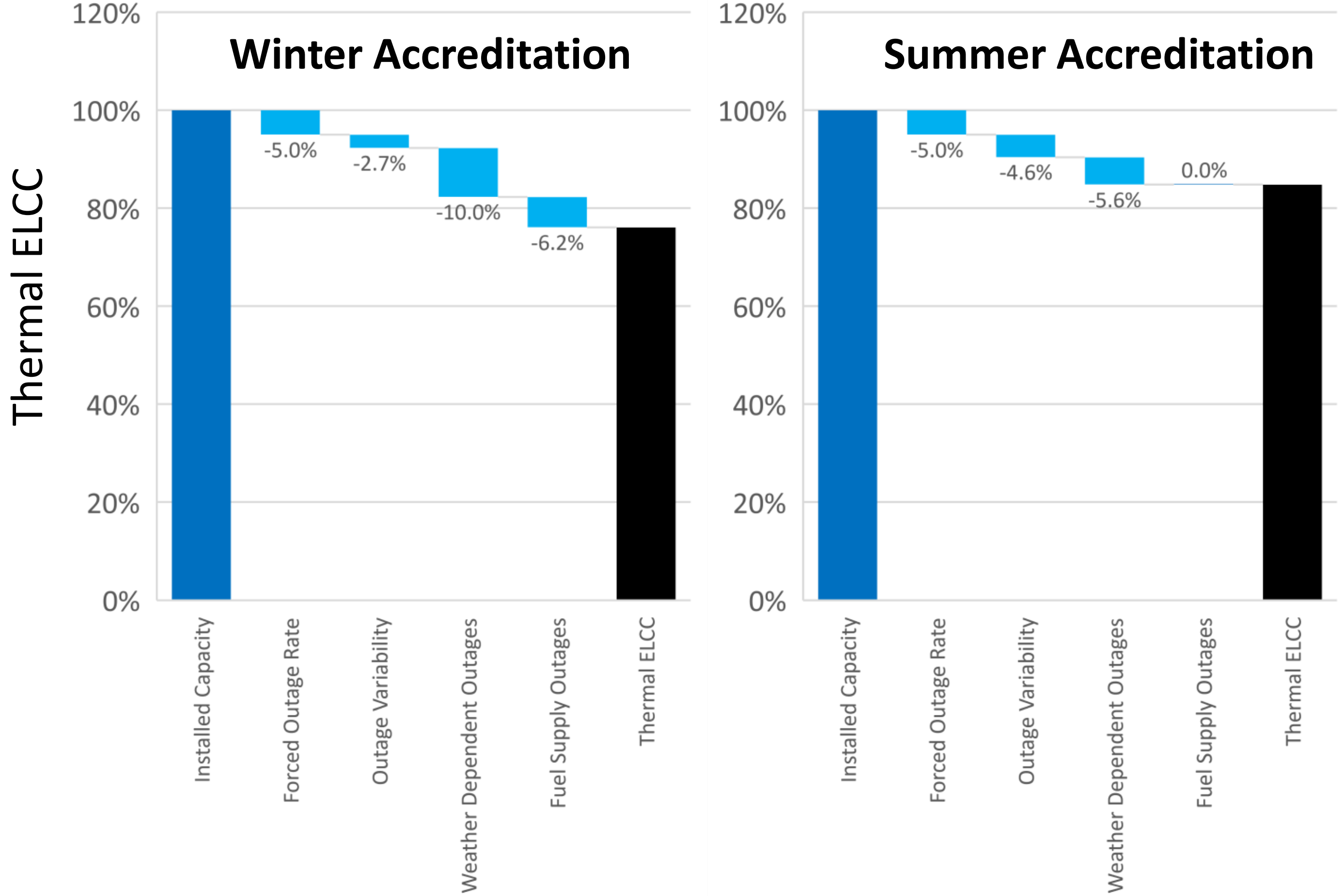
Capacity Accreditation for All

UCAP accreditation may not be a good proxy for perfectly available capacity when accounting for fleet wide interactions of thermal resources

Key fleet wide interactive outage effect categories include:

- Outage variability
- Common mode failures
- Weather dependent outages
- Fuel availability outages



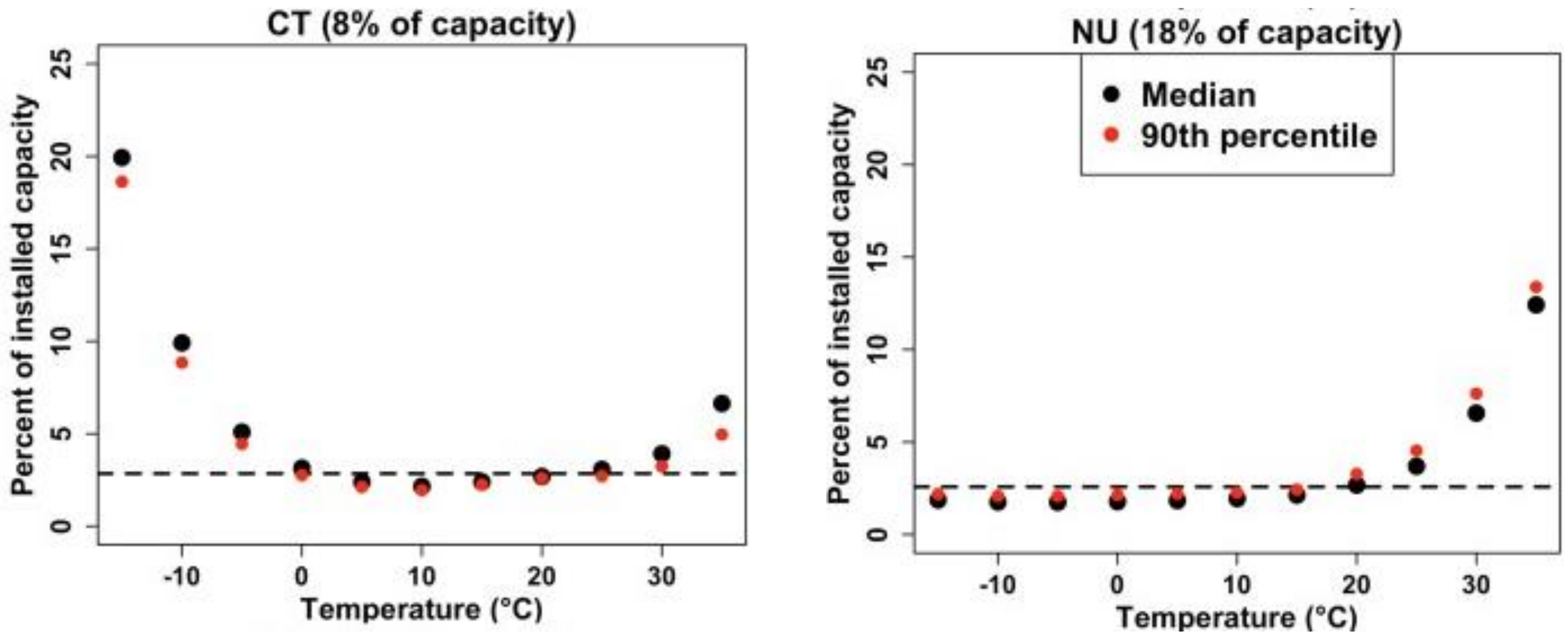
Data Source: Astrape, 2022 (Chart by Telos Energy)
[Accrediting Resource Adequacy Value to Thermal Generation]

We need more granular forced outage data

To capture weather dependencies by generating units

GADS+ could include anonymized:

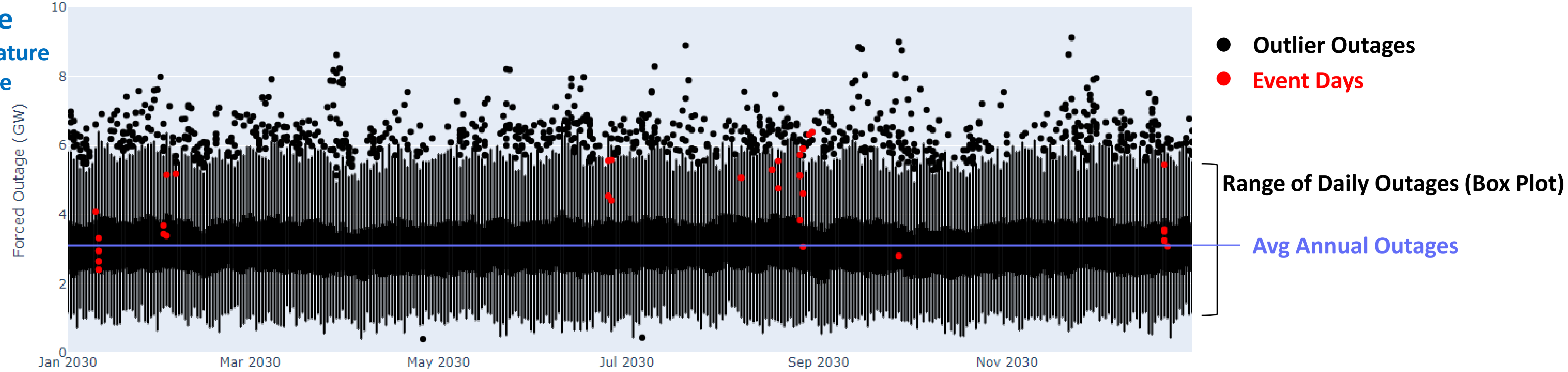
- Daily outage rates by unit
- Locational outage rates (by weather zone)
- Long historical record to include outlier weather conditions
- Simulated performance during weather events
- Control equipment (weatherization, chillers, etc.)



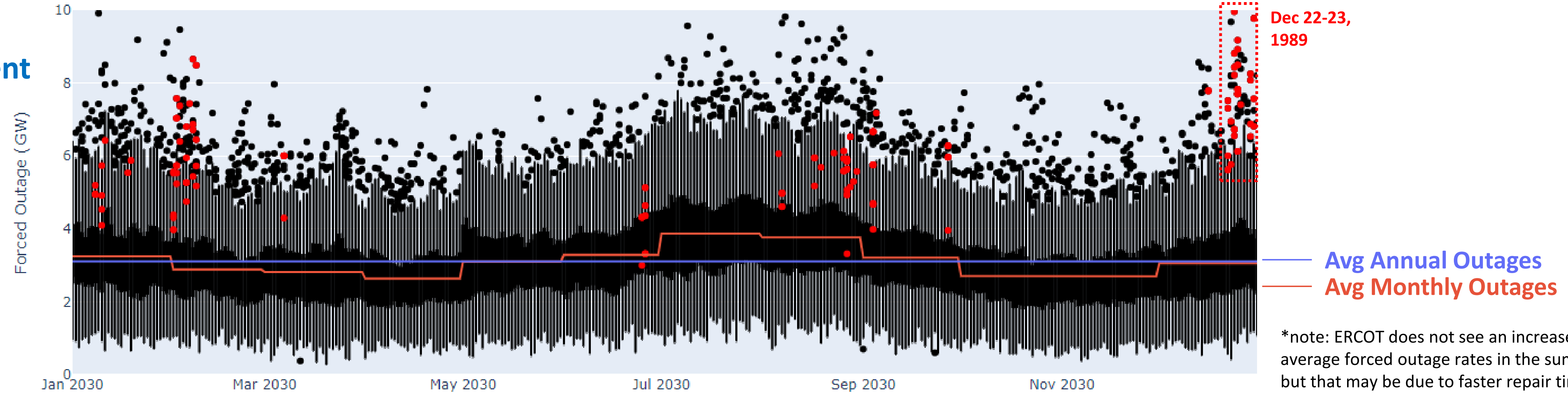
Source: Murphy, S., et al, 2022
[A time-dependent model of generator failures and recoveries captures correlated events and quantifies temperature dependence]

Evaluating system risk with weather dependent outages

Base Case
No Temperature Dependence



Weather Dependent Outages



*note: ERCOT does not see an increase in average forced outage rates in the summer, but that may be due to faster repair times
Source: ERCOT Annual Reports 2012-2020

Source: EPRI, *preliminary* & *forthcoming*
[Resource Adequacy for a Decarbonized Future]

What comes next?

There's more work to be done, especially to evaluate load flexibility and to establish the reliability criteria for the future

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Thank You!

Questions?

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Sources

- **Astrapé Consulting,** *Accrediting Resource Adequacy Value to Thermal Generation,* March 2022, https://info.aee.net/hubfs/Accrediting%20Resource%20Adequacy%20Value%20to%20Thermal%20Generation-1.pdf
- **Energy and Environmental Economics, Inc. (E3),** *Resource Adequacy in the Desert Southwest*, February 2022, https://www.ethree.com/wp-content/uploads/2022/02/E3_SW_Resource_Adequacy_Final_Report_FINAL.pdf
- **Electric Power Research Institute (EPRI),** Resource Adequacy for a Decarbonized Future, ongoing, https://www.epri.com/resource-adequacy
- **Energy Systems Integration Group (ESIG),** *Multi-Value Transmission Planning for a Clean Energy Future,* June 2022, https://www.esig.energy/multi-value-transmission-planning-report/
- **European Network of Transmission System Operators for Electricity** (ENTSO-E), *2021 European Resource Adequacy Assessment (ERAA), https://www.entsoe.eu/outlooks/eraa/2021*
- **GridLab**, *Advancing resource adequacy analysis with the GridPath RA Toolkit: A case study of the Western US*, October 2022, https://gridlab.org/GridPathRAToolkit/
- **GridLab,** *Reliability reaching California's clean electricity targets: Stress testing an accelerated 2030 clean portfolio,* 2022, https://gridlab.org/california-2030-study/
- **Mid-Continent Independent System Operator (MISO)**, *2021 Regional Resource Assessment (RRA), https://cdn.misoenergy.org/2021%20Regional%20Resource%20Assessment%20Report606397.pdf*
- **Murphy, S., Sowell, F., Apt, J.,** *A time-dependent model of generator failures and recoveries captures correlated events and quantifies temperature dependence, Applied Energy, 253 (2019), https://www.sciencedirect.com/science/article/pii/S0306261919311870?via%3Dihub#f0005*