Including High Impact Events in System Planning Scenarios

Managing risk and uncertainty with increasing weather dependency

G-PST/ESIG Webinar | August 14, 2024

TELOS ENERGY

Factors leading to challenging reliability conditions

Tightening reserve margins
by design – do we have the right resource adequacy criteria?

Natural gas as the primary fuel source
missing weather dependent outages and gas electric coordination

Retirements and replacements
requires more robust accreditation methods to ensure we are replacing similar amounts of effective capacity for RA

Lack of interregional transmission and planning
Each region is meeting its own reliability needs, missing opportunities in geographic diversity

Increasing weather dependency of the power system
Natural gas sector, thermal outages, increased wind and solar, electrification

Increasing weather dependency of the power system

Weather Dependent Outages

Increased reliance on wind & solar

Electrification of transportation and heating

Climate Change

Not only are we seeing new risk, but also new uncertainty

"**Risk** is ***something that you can put a price on.*** Say that you'll win a poker hand unless your opponent draws to an inside straight: the chances of that happening are exactly 1 chance in 11. This is risk. It is not pleasant when you take a "bad beat" in poker, **but at least you know the odds of it and can account for it ahead of time.** In the long run, you'll make a profit from your opponent's making desperate draws with insufficient odds.

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Uncertainty on the other hand, is ***risk that is hard to measure*****.** You might have some vague awareness of the demons lurking out there. You might even be acutely concerned about them. But you have no real idea how many of them there are or when they might strike. Your back-of-the-envelope estimate might be off by a factor of 100 or by a factor of 1,000; there is no good way to know. This is uncertainty.

Risk greases the wheels of a free-market economy; uncertainty grinds them to a halt."

-Nate Silver, *The Signal and the Noise*

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Risk is something we evaluate in resource adequacy. It drives our capacity markets and IRPs & we've gotten pretty good at it.

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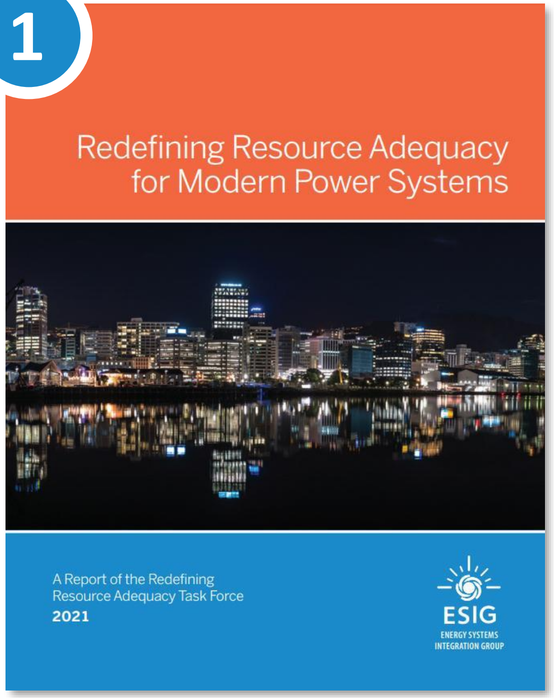
Uncertainty is something we are all concerned about, but don't have a great framework to handle in power system planning.

New criteria to evaluate tail risk

New Resource Adequacy Criteria for the Energy Transition: Modernizing Reliability Requirements

ESIG Redefining Resource Adequacy Task Force

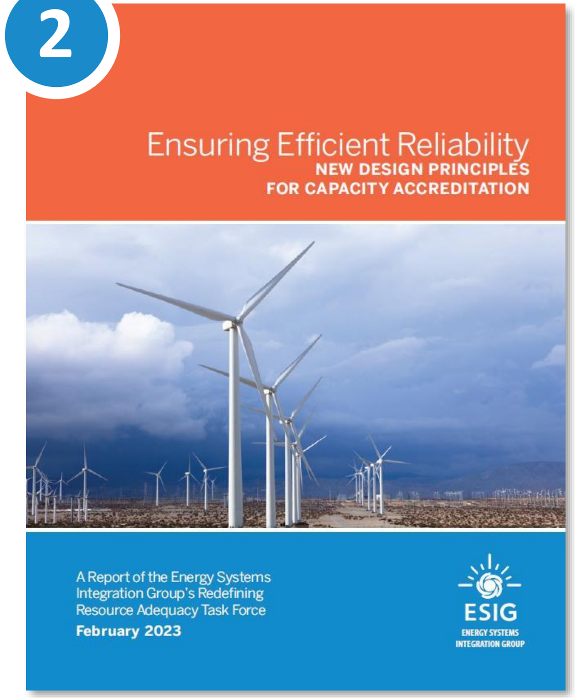
1



Probabilistic Analysis & First Principles

Chronology
& Correlation

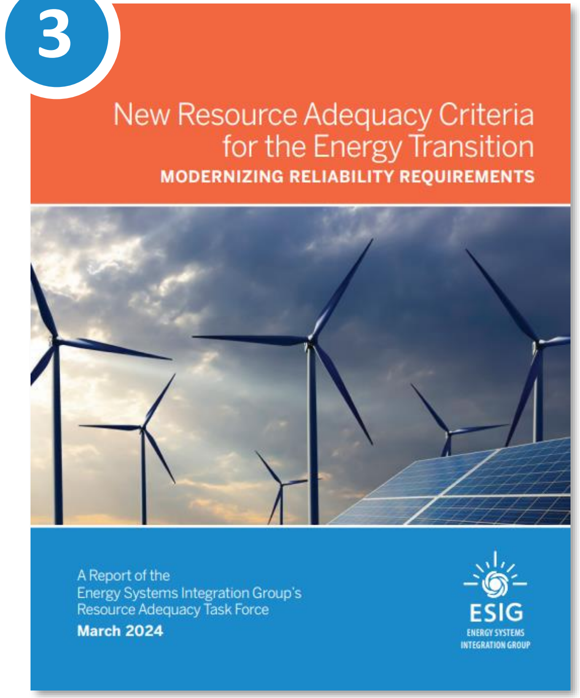
2



Capacity Accreditation and Procurement

Capacity accreditation for all resources

3



New Reliability Criteria & Capacity Needs

Moving beyond
1-day-in-10 LOLE

Get the latest report here!

Building blocks of resource adequacy

Adequacy assessments and studies

- Forward looking, probabilistic resource adequacy simulations
- What is the collective adequacy of the entire power supply?

Resource Adequacy Metrics

- Quantifies resource adequacy risk
- What is the size, frequency, duration, and timing of system risk?

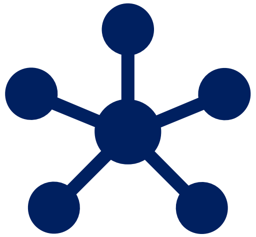
Capacity Accreditation

- Measures the capacity contributions of individual resources (or classes of resources)
- How do resources compare to one another for their RA benefits?

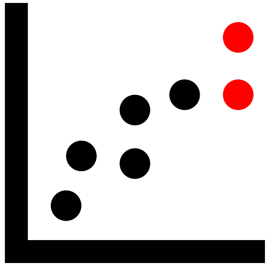
Resource Adequacy Criteria

- Sets the threshold for an acceptable level of risk
- How adequate of a system should we have?

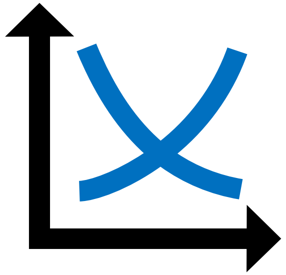
Final Recommendations from the Task Force



1 **Transition to a multi-metric criteria**



2 **Specifically consider extreme events**



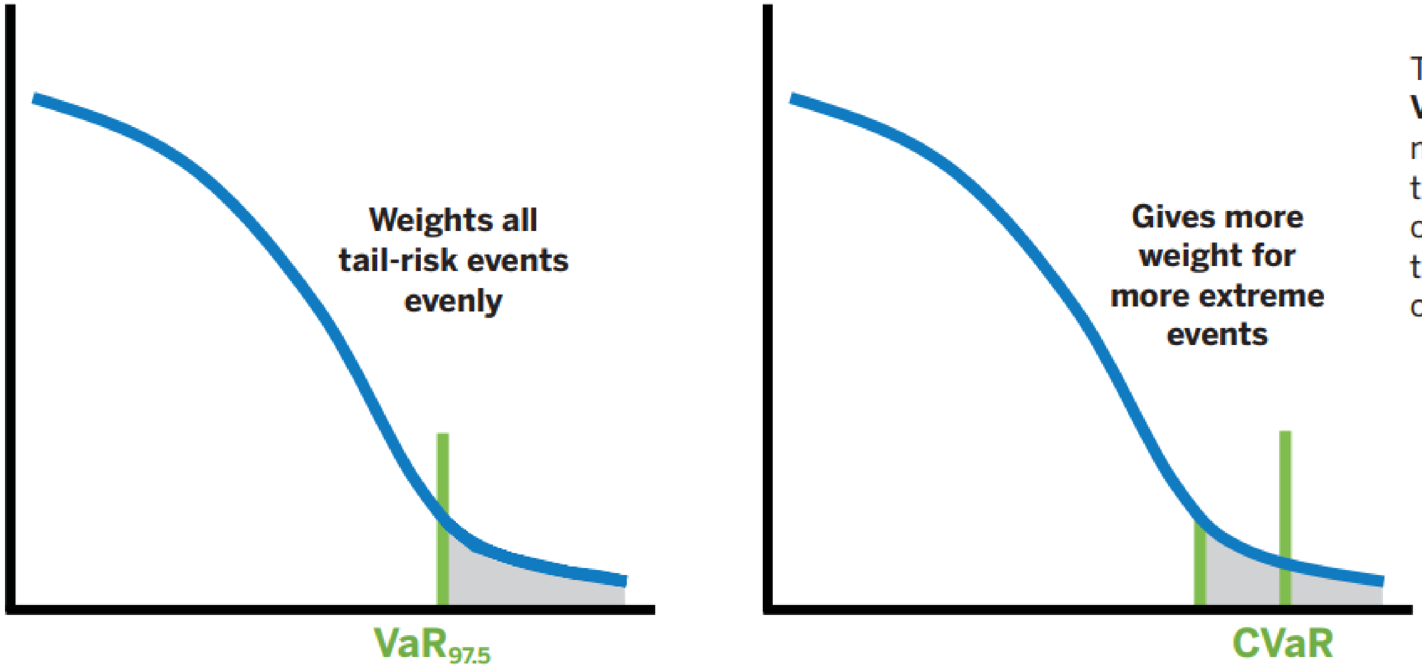
3 **Incorporate economics**

Source: *New Resource Adequacy Criteria for the Energy Transition*

Specifically consider extreme events

Not all resource adequacy loss-of-load events are the same. Tail risks can have a disproportionate impact on reliability and costs and should be quantified

The **Value at Risk (VaR)** metric notes the size or duration of the largest and longest shortfall event for each simulation year (including zero for years with no events) and notes the N^{th} percentile of observations.

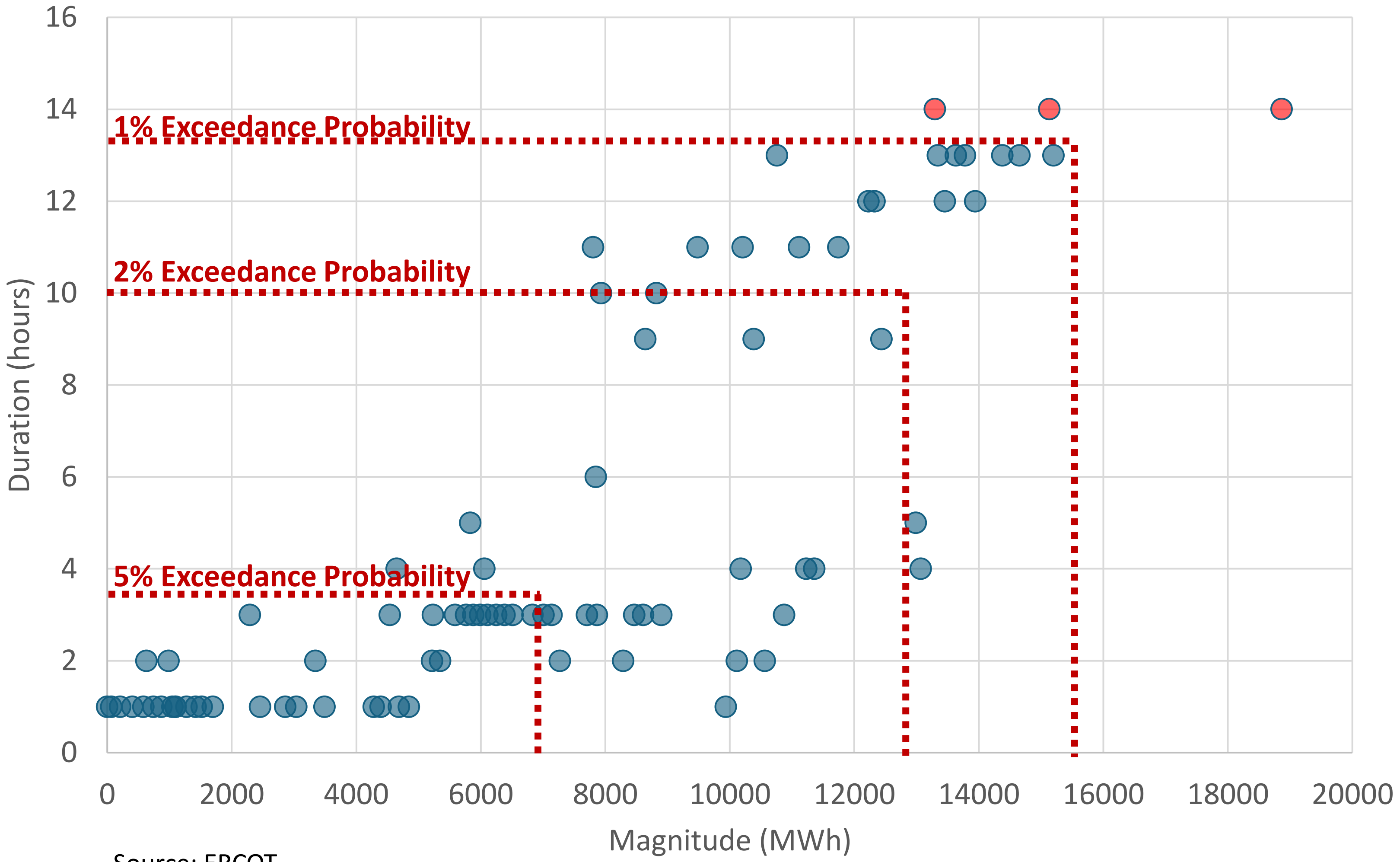


The **Conditional Value at Risk (CVaR)** metric calculates the average of the observations above the N^{th} percentile of observations.

Size of Shortfall Events -or- Energy (MWh) -or- Peak (MW)

Source: *New Resource Adequacy Criteria for the Energy Transition*

Not all resource deficiencies are equal



Source: ERCOT

Today's resource adequacy metrics (LOLE, LOLH, etc.) give all shortfall events equal weighting…

… but some events are more equal than others

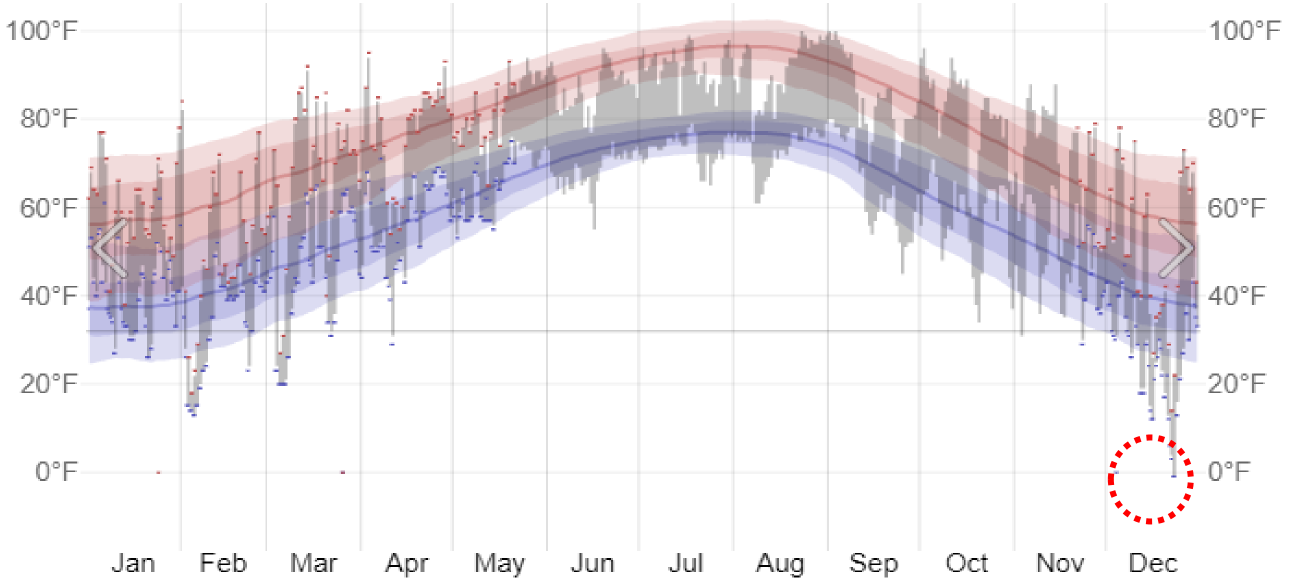
Outlier events… low probability of occurring but 100% loss of load probability when they do occur

ERCOT Top 5 LOLP Days – **high renewable portfolio**

Weather Year	Date	Daily Min/Max Temp (Austin)	Daily LOLP (%)
1982	Jan 11	11 / 30°F	76%
1989	Dec 22	12 / 23°F	100%
1989	Dec 23	4 / 29°F	72%
1985	Feb 2	14 / 30°F	100%
1985	Feb 1	19 / 23°F	96%

Source: Telos Energy, EPRI
https://www.epri.com/research/programs/067417/results/3002027838

1989 Austin Temperature

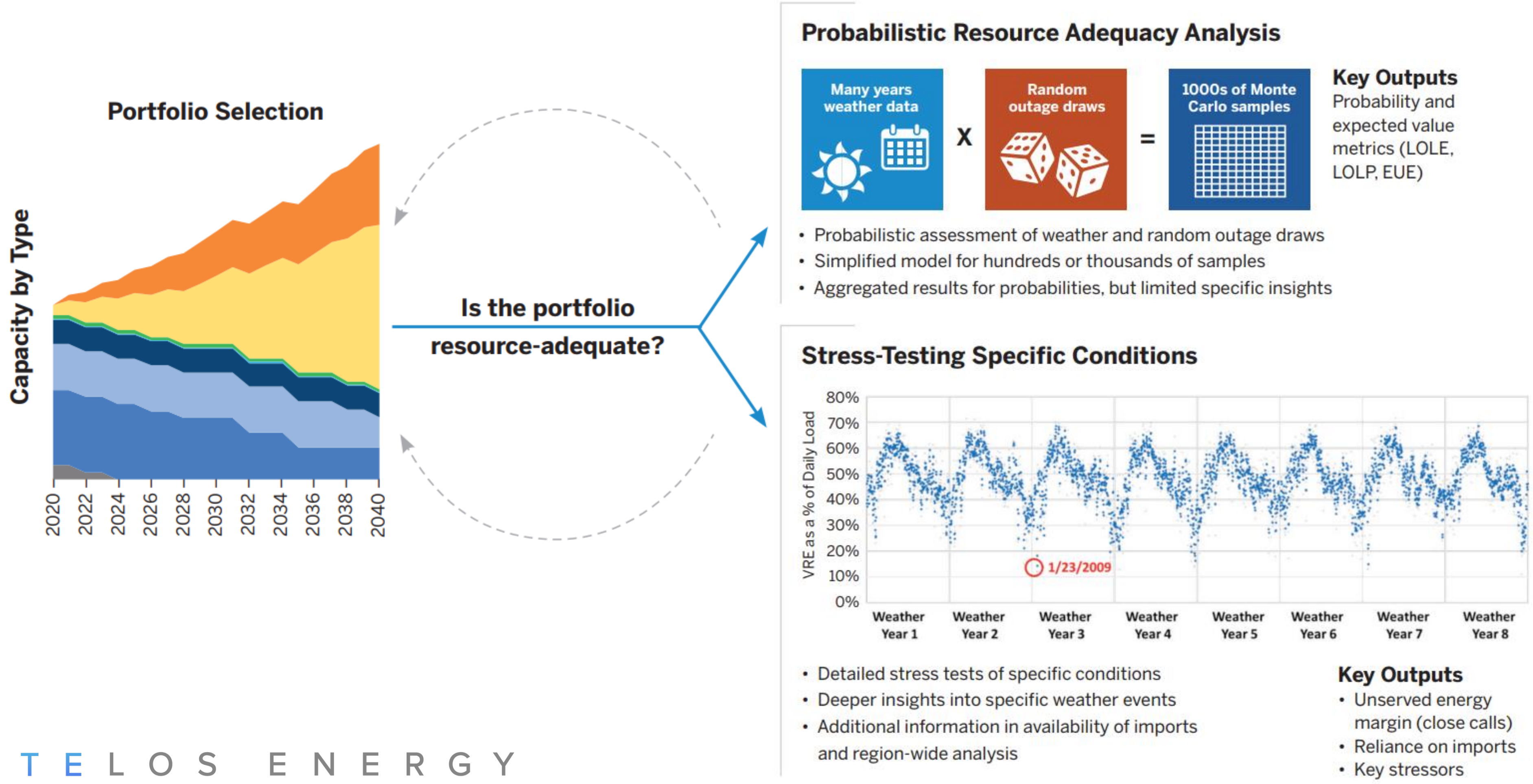


Source: WeatherSpark.com

>80% of all loss of load days occurs during top five days across the 40-year, 14,600 day, sample.

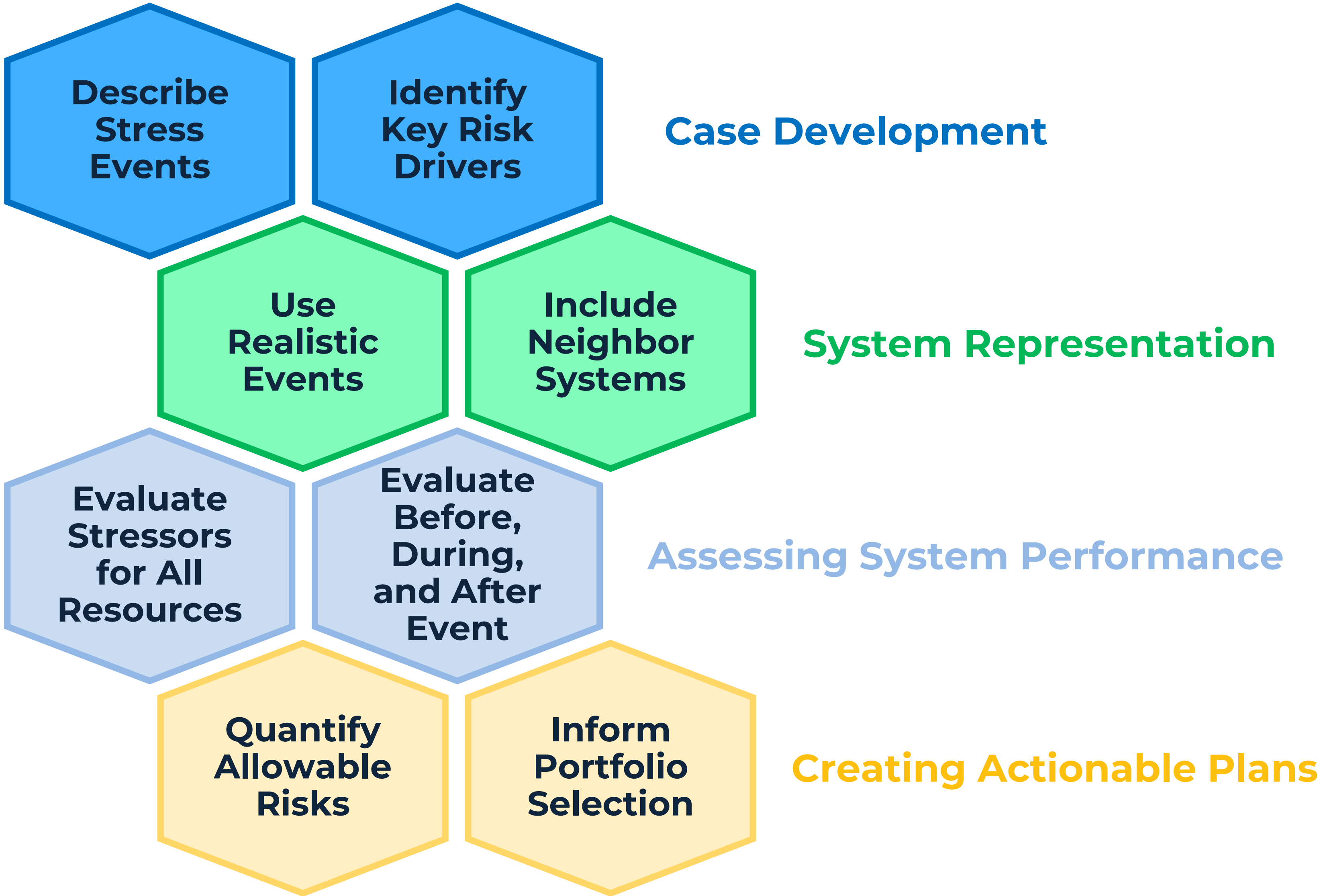
Specifically consider extreme events

Limited data are available to determine with confidence the probability of extreme events. This reality may require discrete analysis or stress-testing



Best practices for stress testing

Incorporating uncertainty in resource planning and procurement decisions


Describe Stress Events
Identify Key Risk Drivers
Case Development
Use Realistic Events
Include Neighbor Systems
System Representation
Evaluate Stressors for All Resources
Evaluate Before, During, and After Event
Assessing System Performance
Quantify Allowable Risks
Inform Portfolio Selection
Creating Actionable Plans

Stress Testing Framework

Portfolio Development (internal and external resources)

- Regional BAU
- High RE + High Electrification

Stress Events

Extreme Event Characterization

- Winter Cold Snap
- Summer Heat Wave
- VRE Drought
- Others

Operational Factors

- Correlated unit outages
- Hourly load, wind, solar
- Extreme event transmission network stressors (on regional interfaces)
- **Available external resources (Hourly Energy Margin)**
- Detailed unit commitment, dispatch, and ramping
- Hourly operating reserves

Stress Testing Variables

- Load forecast error
- Transmission deratings
- Fuel supply disruptions
- **Interregional resource availability**
- Internal resource availability
- **Incorporate climate trends**

Stress Test Output

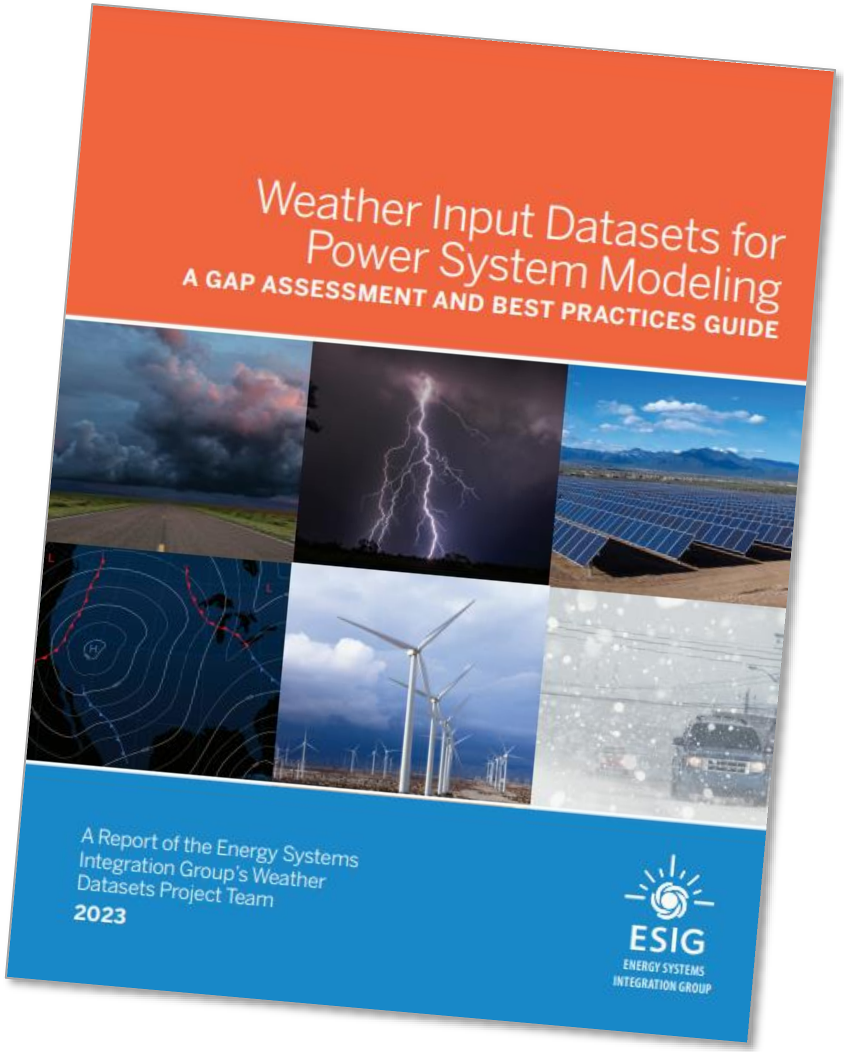
Energy deficiency
EEA occurrences
Reserve deficiencies
Unscheduled flows

To do this well, we need better weather data!!

Weather data modeling gaps…

dealing with imperfect data

Including the necessary variables	Wind, solar, temperature, load, etc. *Continental in scale*
Covering multiple decades with ongoing extension	30-40 years minimum
Coincident and physically consistent	Based on real weather phenomena, not statistically derived *Time-synchronized*
Validated	
Documented	
Periodically refreshed	
Available and accessible	



New ESIG Report!

Cross-disciplinary, inter-regional research and development is necessary

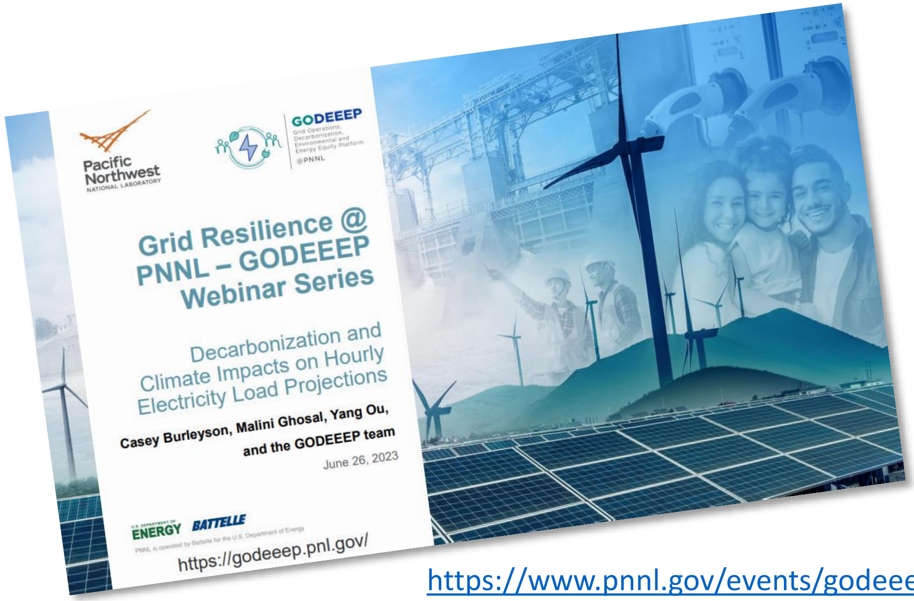
Screening for challenging weather events

Burleyson, C., Thurber, T., & Vernon, C. (2023). Projections of Hourly Meteorology by Balancing Authority Based on the IM3/HyperFACETS Thermodynamic Global Warming (TGW) Simulations (v1.0.0) [Data set]. MSD-LIVE Data Repository. https://doi.org/10.57931/1960530

- **43 years (1980-2022) of historical hourly** meteorology +80 years (2020-2099) of projected hourly meteorology
- Dynamical downscaling of historical reanalysis, ERA5 downscaled to higher temporal and spatial resolution using Weather Research and Forecasting Model (WRF)
- 12km model resolution
- Output is first spatially-averaged by county then population-weighted to 54 Balancing Authorities (BAs) in the conterminous United States
- Includes temperature, humidity radiation, wind speed (10-m)
- Includes eight future climate scenarios
- Relying on atmospheric and meteorological science team at PNNL. Telos Energy has not validated the model results

Variables

Variable	Name	Description	Units
Time	Time_UTC	Hour in Coordinated Universal Time	-
Temperature	T2	2-m temperature	K
Specific Humidity	Q2	2-m water vapor mixing ratio	kg kg^{-1}
Shortwave Radiation	SWDOWN	Downwelling shortwave radiative flux at the surface	W m^{-2}
Longwave Radiation	GLW	Downwelling longwave radiative flux at the surface	W m^{-2}
Wind Speed	WSPD	10-m wind speed (derived from U10 and V10)	m s^{-1}



https://www.pnnl.gov/events/godeeep-webinar-series-deep-dive-one

Screening for Extreme Heat and Cold Events

Multi-Day Weather Events

- Calculated three-day rolling average temperatures for both extreme heat and extreme cold to identify multi-day periods of extreme heat/cold

Wide-area assessment

- Aggregated U.S. into 11 regions and evaluated average temperatures across wide areas rather than smaller planning coordinators
- Evaluated the Top 40 extreme heat and cold 3-day periods for reach region and prioritized events that occurred across multiple regions during the same “event”
- Ensured each region had at least its Top 2 worst events covered

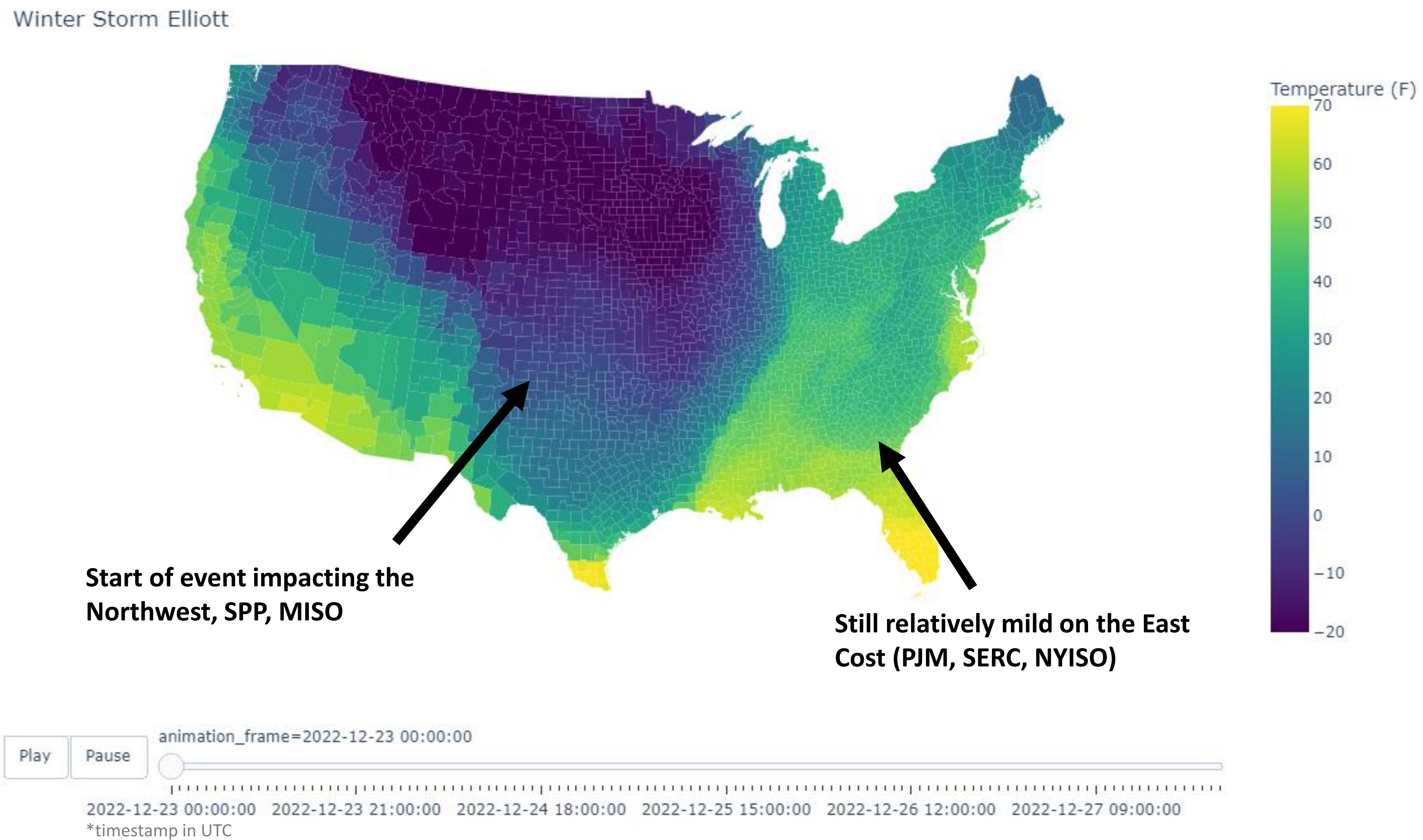
Note: other weather properties will have impacts on power system reliability, including humidity, wind speed, irradiance, month/weekday, etc., but the scope of this analysis and request only considered temperature

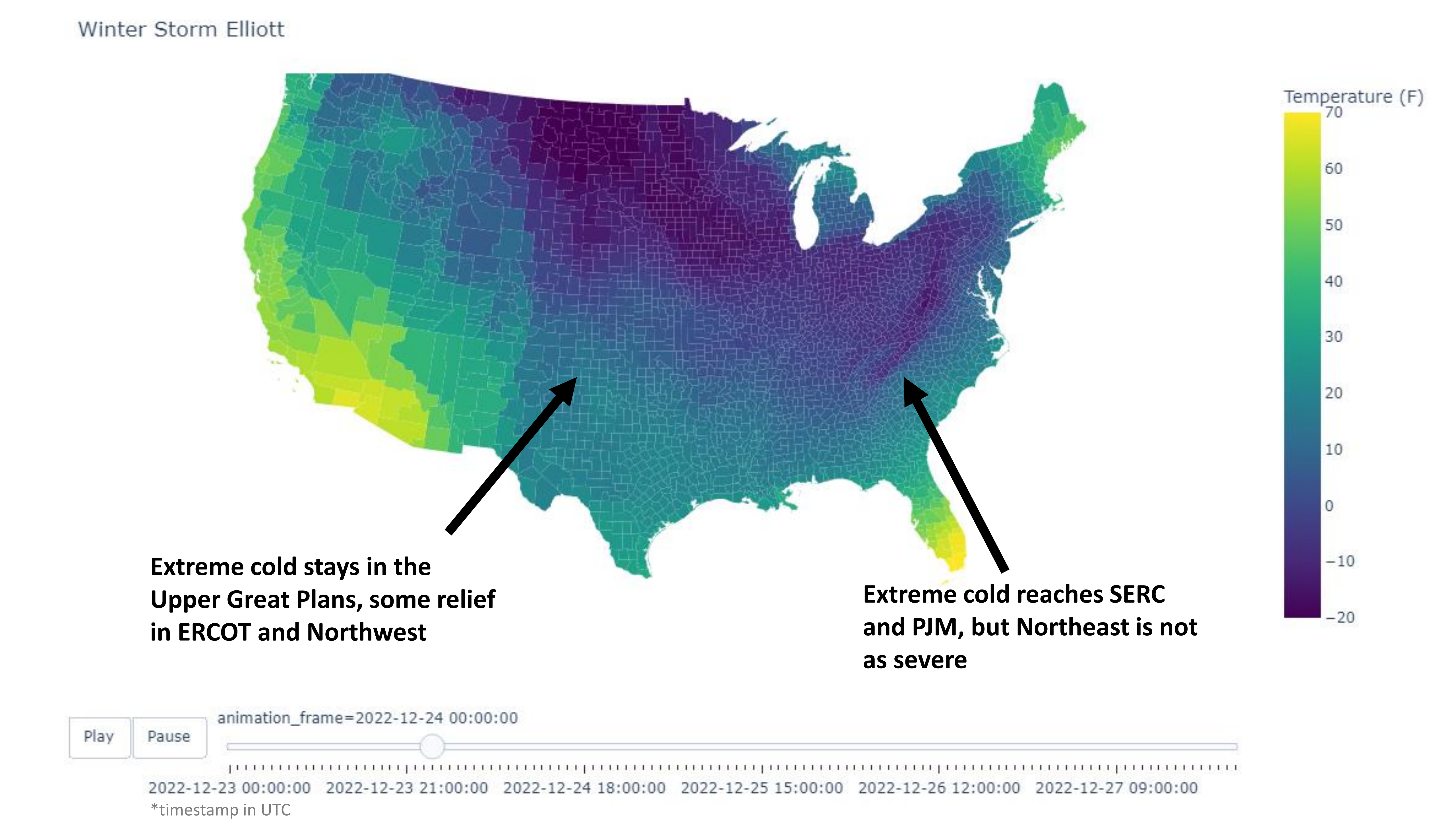
Extreme Cold Events tend to be wide-area. Requires interregional coordination an planning

Rank of events by average three-day average min temperature, 1980-2022

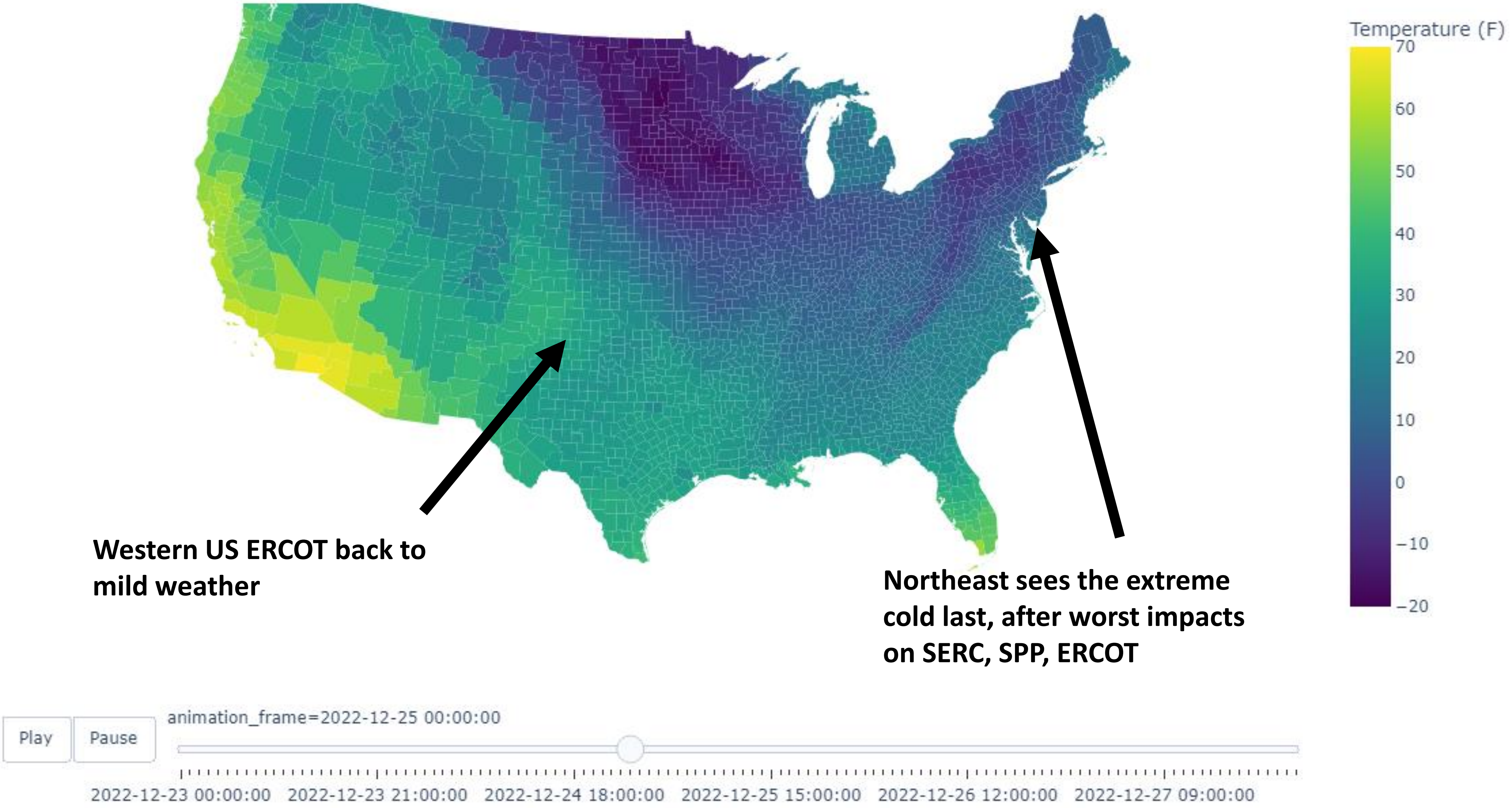
Event Type	Year	Month	WECC NW	CA / MX	WECC SW	ERCOT	SPP	MISO	SERC	FRCC	PJM	NYISO	ISONE	LOWEST RANK	TOP 5 COUNT	SHORTLIST	PRIORITY EVENTS
Cold Event	1981	1							12	4	9	2	1	1	3	1	
Cold Event	1983	12	3			3	2	4	2	3	3			2	7	1	Widespread cold, worst case
Cold Event	1984	1	13			14	13	3	16		2	3		2	3	1	
Cold Event	1985	1				11	10	10	1	1	4			1	3	1	Widespread cold
Cold Event	1989	2	2	2			12			13				2	2	1	
Cold Event	1989	12				1	1	5	3	2	5			1	6	1	
Cold Event	1990	12	1	1	1		16							1	3	1	Western Cold
Cold Event	1994	1						2	7		1	1	3	1	4	1	Eastern Cold
Cold Event	1996	2	11			5	3	1	5		7	16		1	4	1	
Cold Event	2004	1	8									8	2	2	1	1	
Cold Event	2011	2			2	4	11	13						2	2	1	2011 Southwestern Event
Cold Event	2021	2				2	4	14						2	2	1	Winter Storm Uri
Cold Event	2022	12				8	9		6	11				6	0	1	Winter Storm Elliott
Total Cold Events Selected			**6**	**2**	**2**	**8**	**10**	**8**	**8**	**6**	**7**	**5**	**3**			**13**	

Numbers represent rank of event relative to a region's 43-year history. Lower numbers represent more extreme for that region.


Winter Storm Elliott
Temperature (F)
70
60
50
40
30
20
10
0
−10
−20
Start of event impacting the Northwest, SPP, MISO
Still relatively mild on the East Cost (PJM, SERC, NYISO)
Play
Pause
animation_frame=2022-12-23 00:00:00
2022-12-23 00:00:00
2022-12-23 21:00:00
2022-12-24 18:00:00
2022-12-25 15:00:00
2022-12-26 12:00:00
2022-12-27 09:00:00
*timestamp in UTC


Winter Storm Elliott
Temperature (F)
70
60
50
40
30
20
10
0
−10
−20
Extreme cold stays in the Upper Great Plans, some relief in ERCOT and Northwest
Extreme cold reaches SERC and PJM, but Northeast is not as severe
Play
Pause
animation_frame=2022-12-24 00:00:00
2022-12-23 00:00:00
2022-12-23 21:00:00
2022-12-24 18:00:00
2022-12-25 15:00:00
2022-12-26 12:00:00
2022-12-27 09:00:00
*timestamp in UTC

Winter Storm Elliott



Western US ERCOT back to mild weather

Northeast sees the extreme cold last, after worst impacts on SERC, SPP, ERCOT

*timestamp in UTC

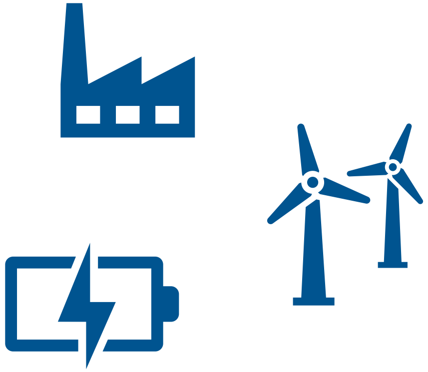
A word of caution… do’s and don’ts of stress testing

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 “Black Swan” events that include high-impact, low probability events for what-if analysis	**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 neighboring grids, including weather, load, and system resource mix in adjacent balancing authorities	**Assume the grid is an island,** without interchange to neighboring systems (unless its an actual island)
Apply stressors to all resource types, including weather dependent outages and fuel limitations	**Assume only renewables** are affected by extreme weather

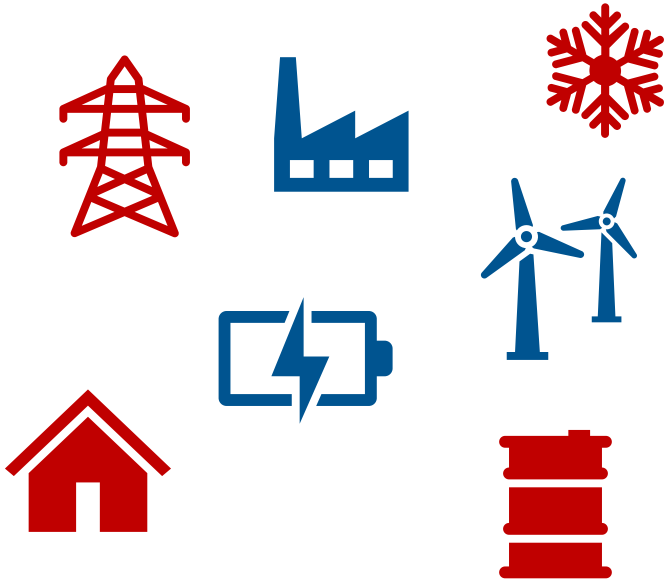
Source: Stenclik, D., “Best Practices for Modeling Extreme Weather in Power Systems Five Do's and Don'ts for Incorporating Weather in Resource Adequacy Analysis, https://www.telos.energy/post/best-practices-for-modeling-extreme-weather-in-power-systems

A word of caution… think broadly to mitigate uncertainty

Mitigate Risk with Capacity



Mitigate Uncertainty with more options



- ✓ Capacity
- ✓ Interregional Transmission
- ✓ Load Flexibility
- ✓ Winterization
- ✓ Dual Fuel Capability
- ✓ Electric-gas coordination

Thank You!

Questions?

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