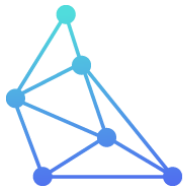
Resilience & a National View of Correlated Outage Risks

Ryan Deyoe | ESIG Spring Workshop, March 2024



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ESIG Transmission Resilience Task Force – Get Involved!

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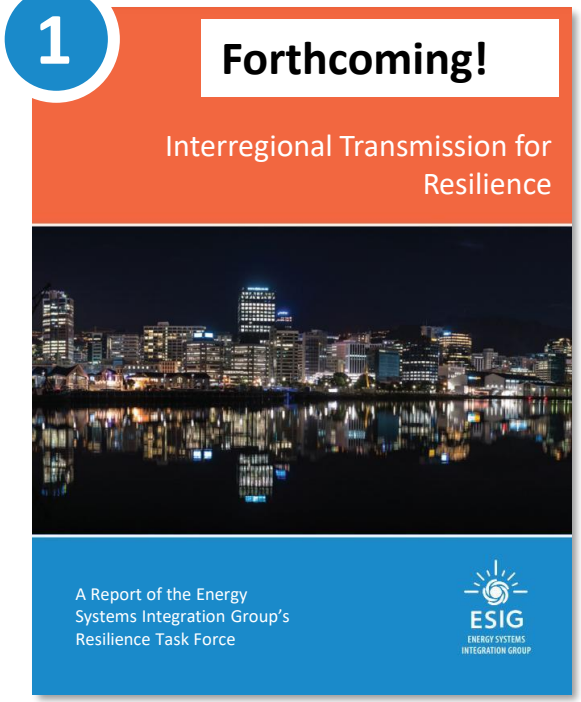
Forthcoming!



Correlated Risks and Identifying Interregional Transmission for Resilience

Hourly energy margin assessment

Efforts are focus on enabling a national assessment of benefits from interregional transmission to improve system resilience **using realistic extreme events** assessed with **time-synchronized** and **correlated datasets**

- ☑ Phase 0 — Determine current interregional transfer limits
- ☑ Phase 1 — National Assessment Weather & Geographic Diversity During Extreme Events
- Phase 2 — Extreme Event Stress Test Analysis
- Phase 3 — Detailed Power Flow & Transmission Analysis

Initial Task Force Results – Hourly Energy Margin Calculation

Objective: To determine periods of high-risk events, an **hourly available capacity margin** for each FERC 1000 region was developed

- ✓ Allows for quick regional assessments of expected resource availability
- ✓ Captures hourly variability in wind and solar output against thermal availability
- × Does not assess actual system dispatch or economic transfers
- × Simplifies hydro availability with seasonal capacity ratings. Does not capture energy limitations of hydro.

Hourly Margin Calculation across Seven Weather Years

+ Available Wind & Solar
+ Seasonal Hydro Capacity
+ Available Thermal
– Weather Dependent Outages } Today's focus
– Expected Maintenance
+ Recallable Maintenance
+ Storage Net Gen
– (Load + Reserve Requirement)

Regional Available Margin

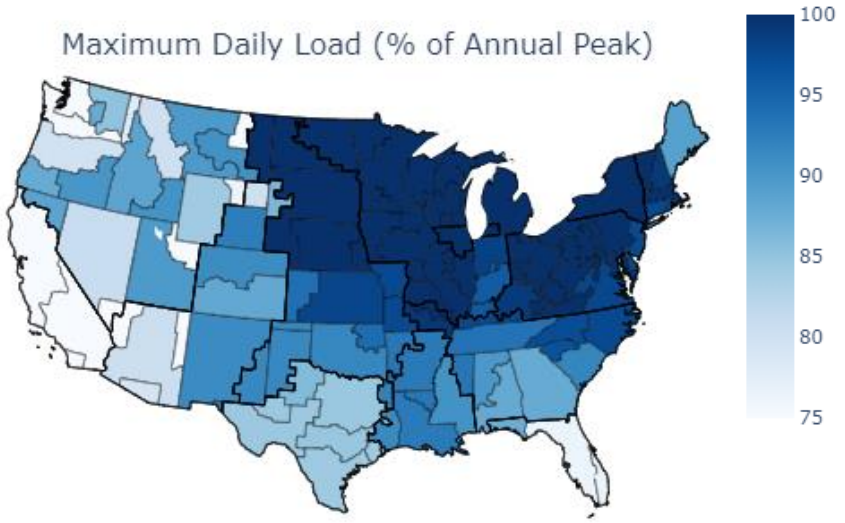
Notes:
1. Storage is dispatched to arbitrage hourly net load within a day
2. Operating Reserves (spin and regulation) are set at 6% of the load
3. Interregional transmission flows are only modeled for reliability/resilience objectives, and flow when reserves drop below 10% of load indicating a reluctance to drop to bare minimum reserve levels of 6%

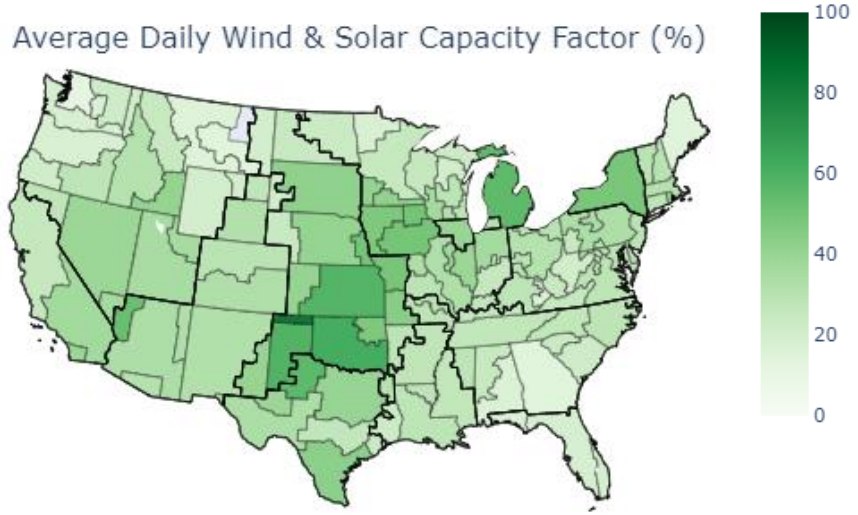
Visualizing the Margin

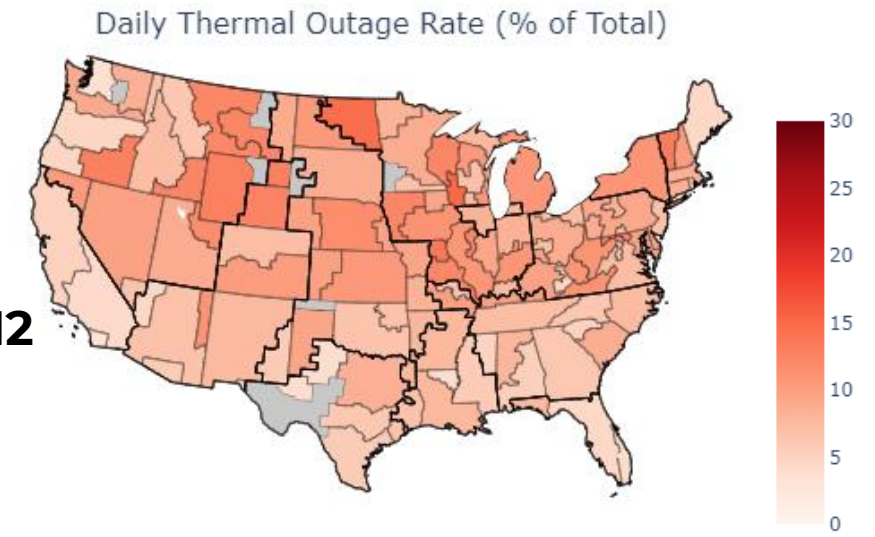
Particularly helpful in showing the movement and regional concentration of grid stressing events

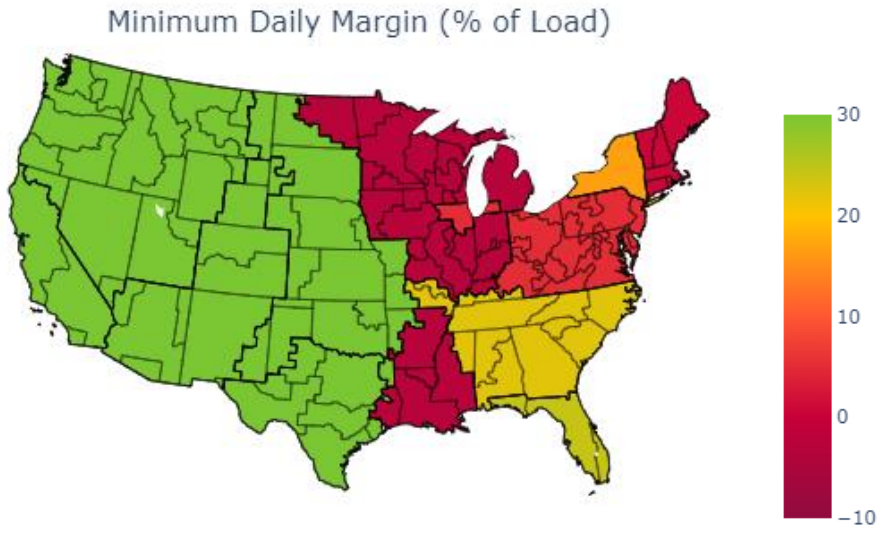
e.g., heat wave in Midwest and mild temperatures and load in the Southwest

July 14, Weather Year 2012









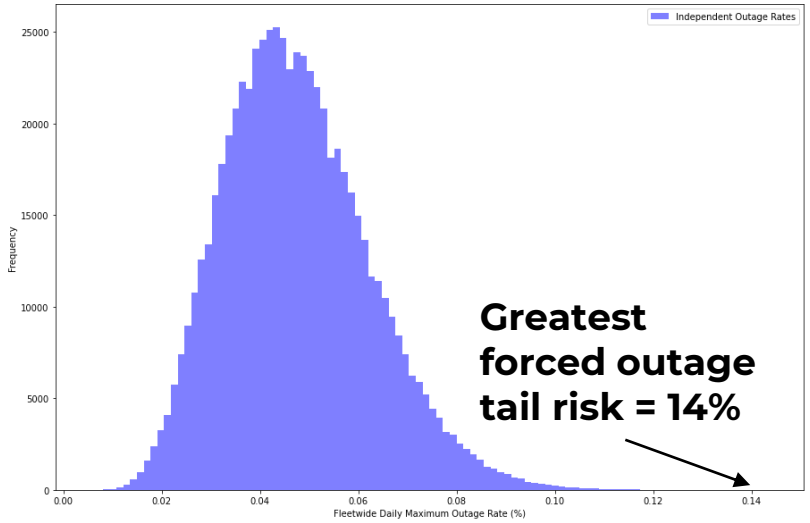
Comparing Outage Modeling Approaches

Important Factors to Consider:

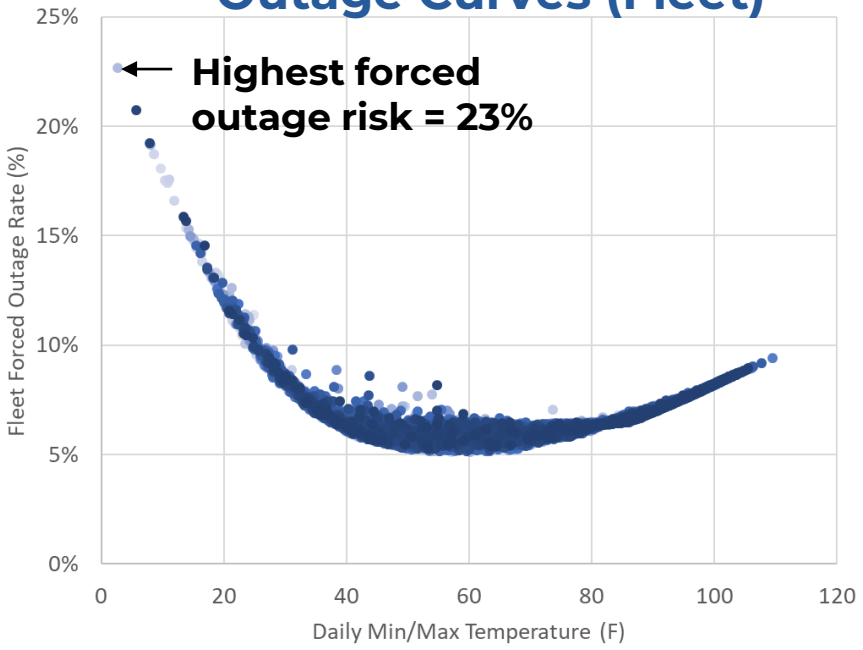
- System-wide failures (fuel supply disruptions)
- Correlated failures (temperature induced mechanical failures)
- Uncorrelated outages (independent mechanical failures)

We are not adequately capturing all these factors with today's approaches!

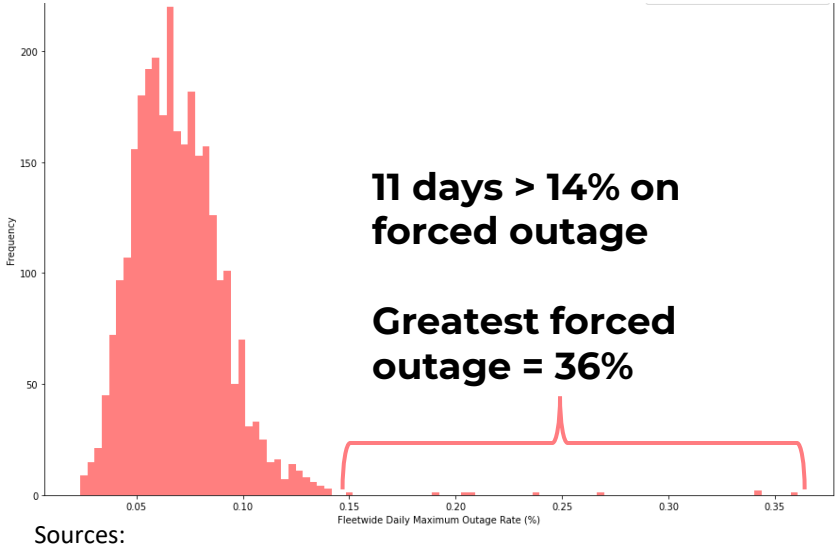
Independent Outage Modeling (Unit-level)



Weather Dependent Outage Curves (Fleet)



GADS Data Distribution (Fleet)



Sources:

1. Telos Energy, EPRI
2. Adapted from S. Murphy (2019)
3. NERC GADS Outage Data 2016-2023. Data aggregated and anonymized in collaboration with NERC for the ITCS project.

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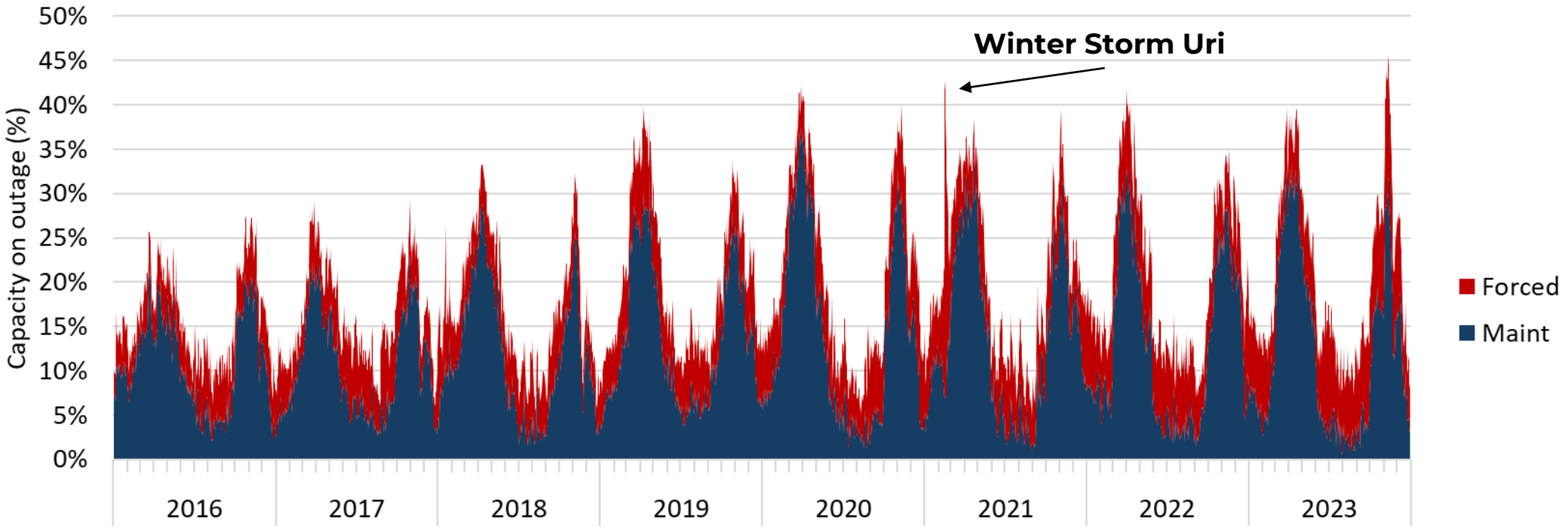
Timing and Geographic Diversity of Extreme Events Matter

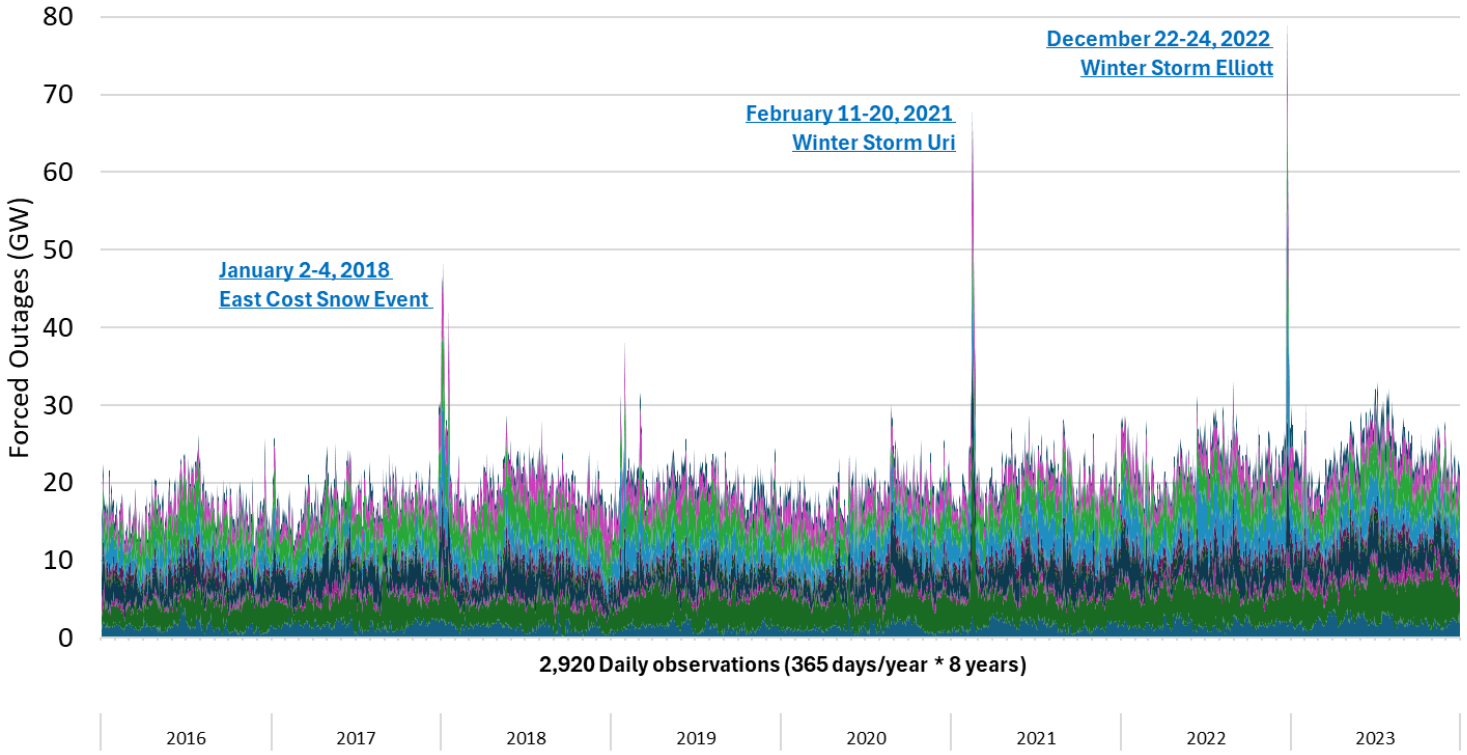
Regions are not unfamiliar with large amount of capacity on outage at once. But the **timing, location and cause of capacity shortfalls matters** but this is not typically captured in **RA or Grid Resilience studies** and **misses opportunities for interregional transmission** to be apparent.

Single Fuel Gas Fleet Maximum Daily Capacity on Outage (% of ICAP)



A Closer Look at Actual Outage Data Collected

Fleetwide Maximum Daily Forced Outage across FERC Order 1000 Regions (2016 – 2023)



Special thanks to Martin William and NERC staff for providing data and support for the GADS datasets

What: Daily Fleet-wide outage rate statistics (max, avg, min)

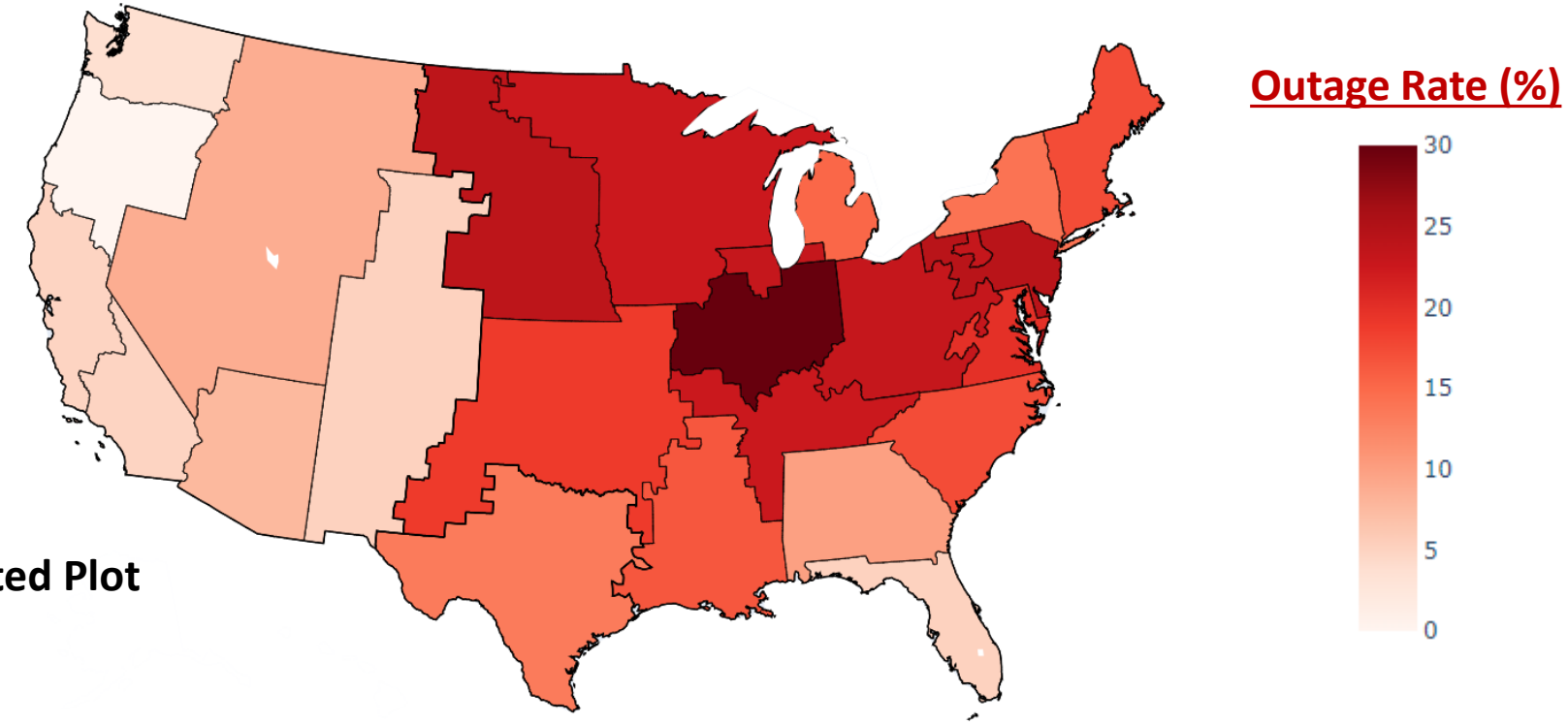
Where: Aggregated to state, FERC 1000, ACPF regions

When: Time-synchronized from 2016 - 2023

Why: Provide a geographic and time-synchronized view of outages and resource availability across the country

Timelapse of Outage Risks across the Country

Fleetwide Outage Rates Across NERC ACPF Sub-regions
(Winter Storm Elliott Dec. 24th)



Placeholder for Animated Plot

Caveats

- Data cleaning is still in progress and results may change
- Values represent maximum outages per day as a % of ICAP

Leveraging GADS Actual Data for Daily Outages

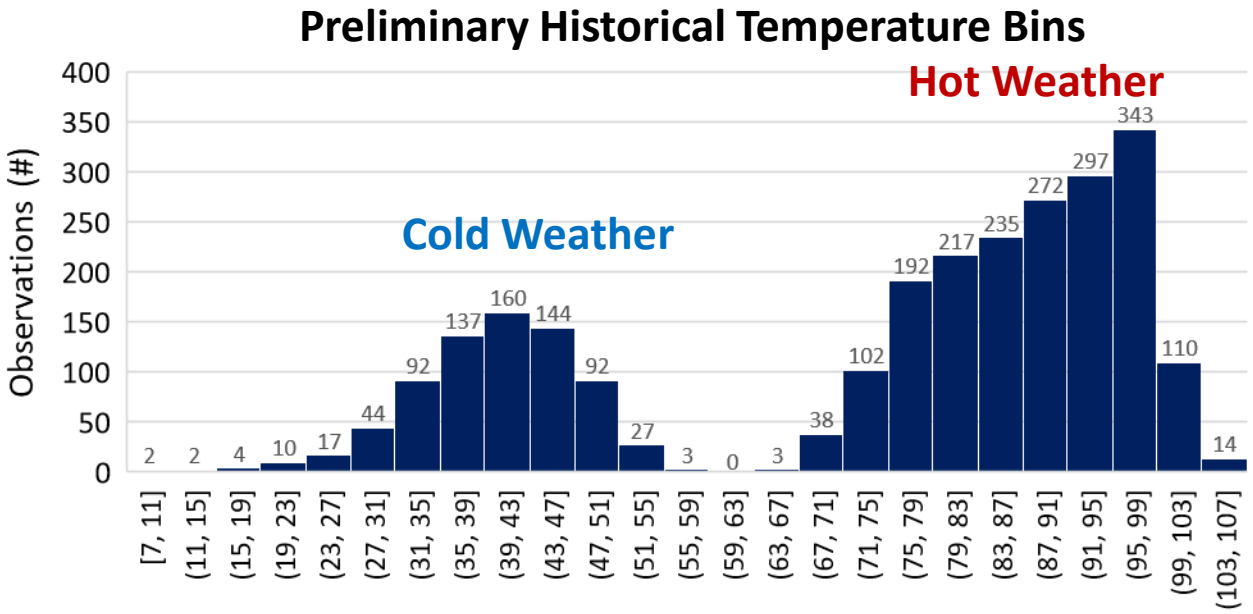
Method: Assign bins for actual daily outage rates by region with respect to temperature data

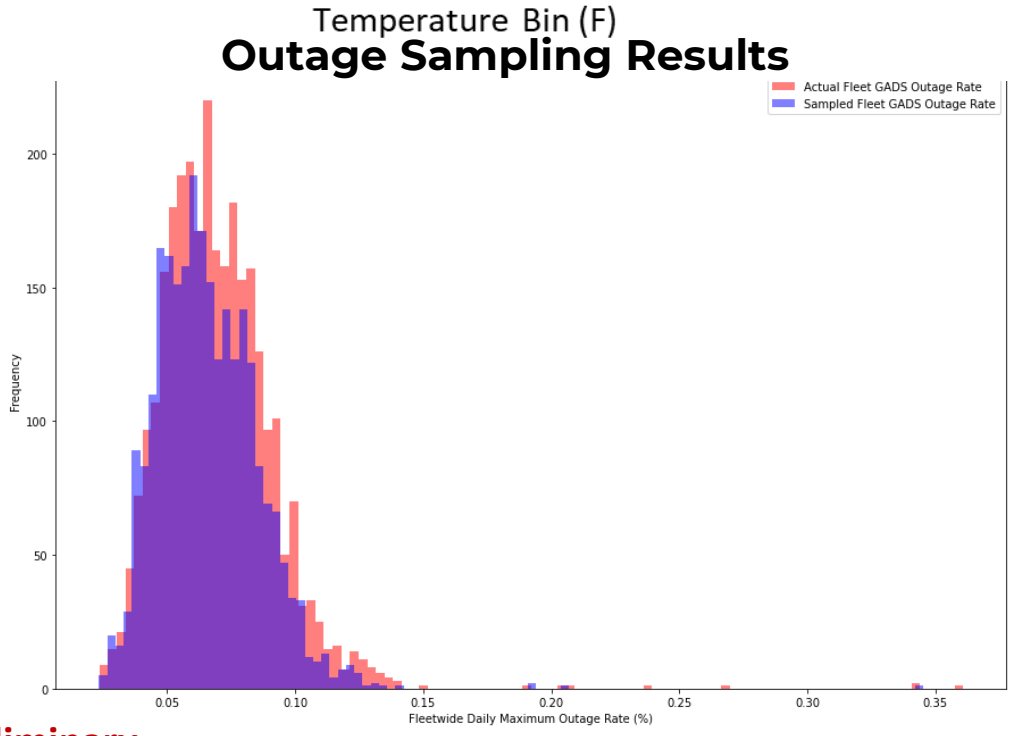
- Method adapted from Patricio Rocha-Garrido (PJM) efforts to account for correlated outages during Elliott

Results: New daily outage rates for different weather years created by sampling temperature-outage bins from historical data

Next Steps: Validate severity of events against historical data.

- Do extreme outages line up with extreme weather?
- Do we overstate severe weather risks?





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Data represented is preliminary

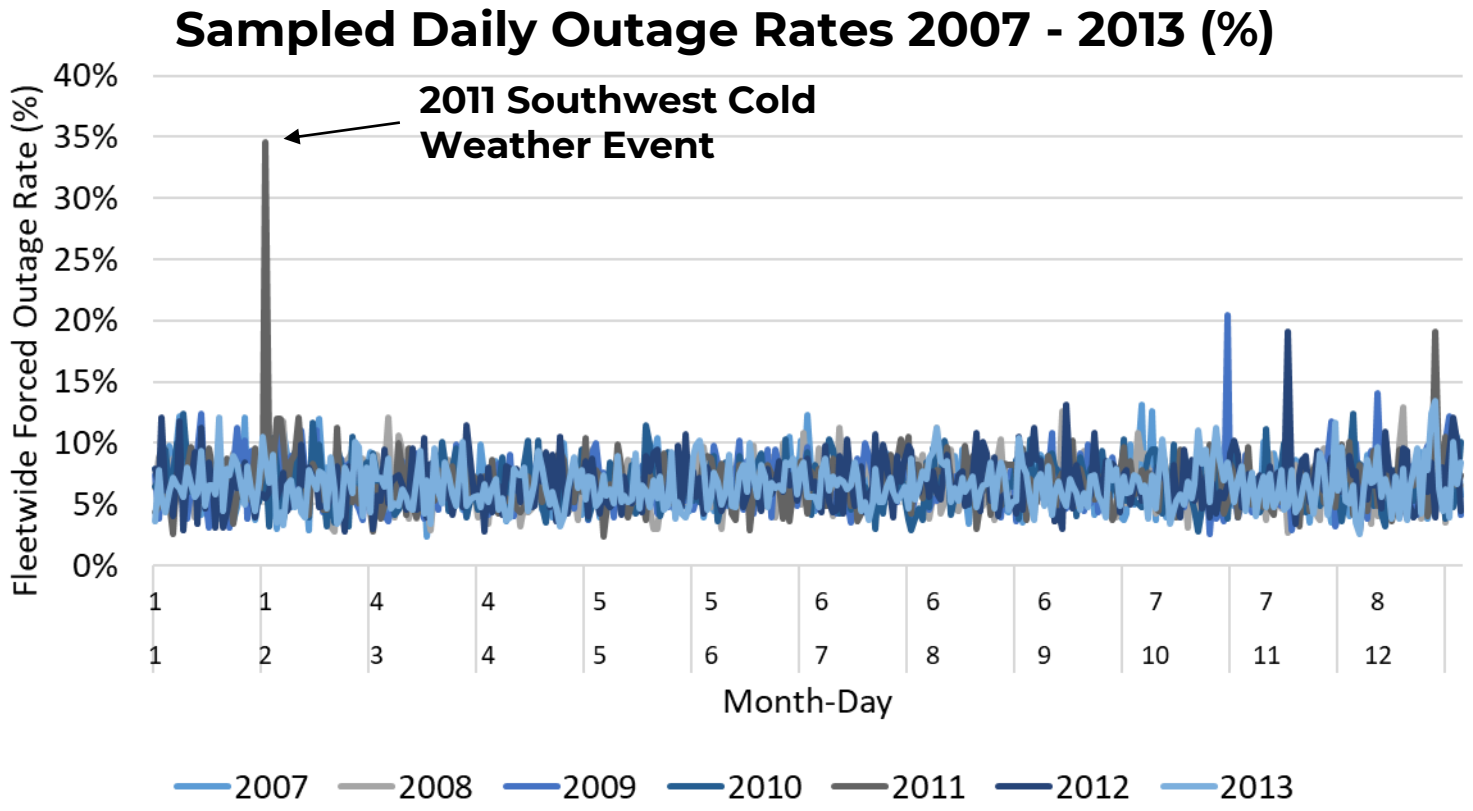
Comparison of Samples to History

Historical Data Comparison: Temperature-Outage sampling was done on historical years outside the GADS dataset for 2007 – 2013.

Results: Good alignment with fleet-wide outages in the affected regions for the 2011 Southwest cold weather event

Caveats:

- Outage data represents historical Max Daily outages
- Duration of events is daily when outages can be multiple days – to be addressed



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Takeaways & Industry Needs

Takeaways

1. Knowing what is happening beyond your own system is important
2. A national-scale dataset can provide insights for better interregional planning
3. Interregional power flows are a natural hedge against local extremes
4. The adequacy of traditional outage methods needs review

Industry Needs

Data Needs

- **Publicly available datasets** will help improve risk assessment methods across the industry.
- **Enhanced data reporting for outage events** may be needed to ensure correlated and independent events are captured.
- **Outage data for solar, wind, and battery storage** must be collected and assessed for correlated risks due to extreme weather.

Extreme Weather Modeling

- **Representing probable extreme events**, and their outsized impacts, is key to planning a resilient system

ESIG Task Force Phase 2

Objective: Assess grid performance across many samples of different grid conditions while representing detailed operating constraints for three 2-week stress events inclusive of interregional transmission representation

Portfolio Development

- Regional BAU
- High RE + High Electrification

Stress Events

Extreme Event Characterization

- Winter Cold Snap
- Summer Heat Wave
- VRE Drought

From Phase 1

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

Stress Test Output

Energy deficiency
EEA occurrences
Reserve deficiencies
Unscheduled flows