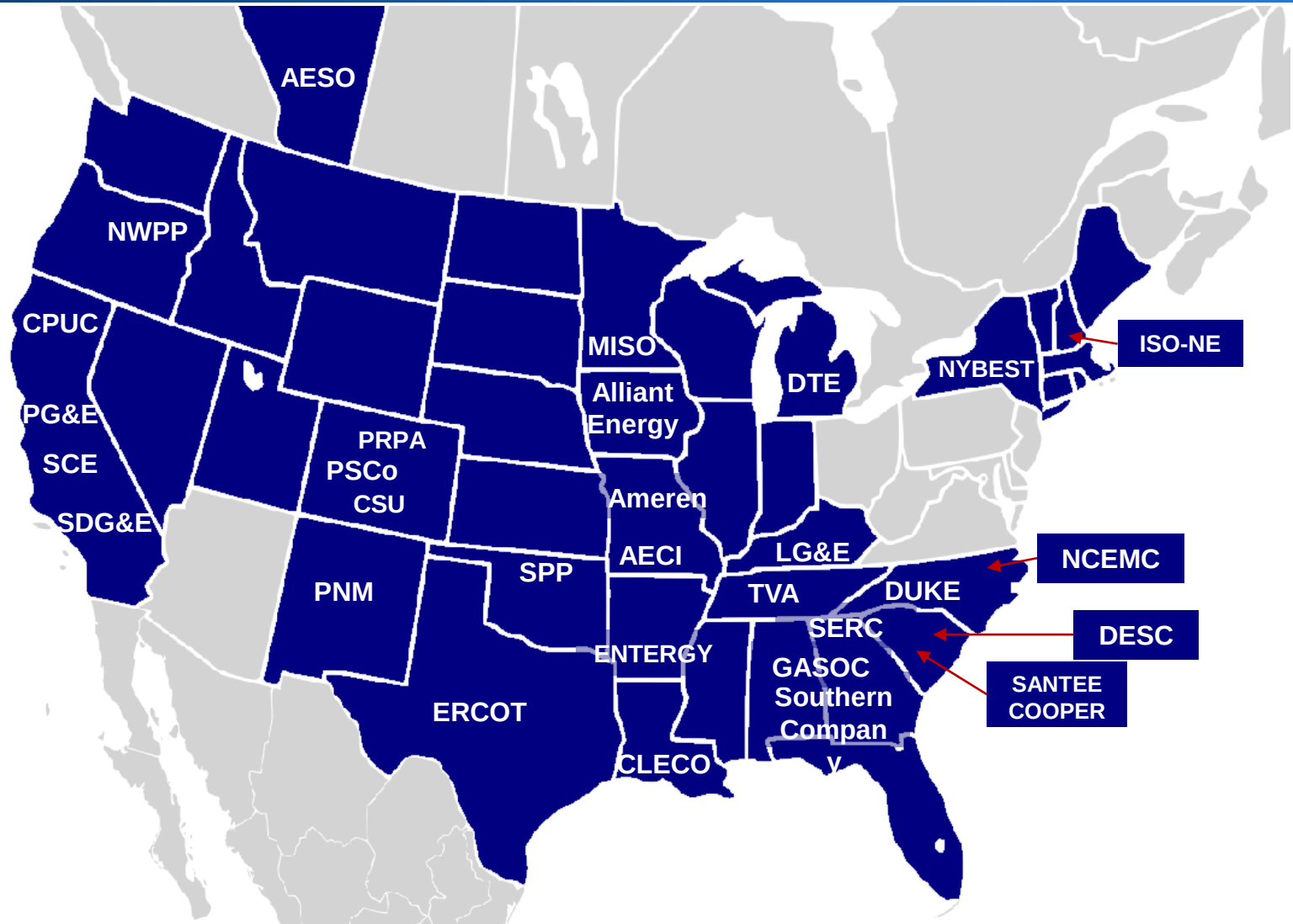


Resource Accreditation Considering Correlated Outages

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10/26/22

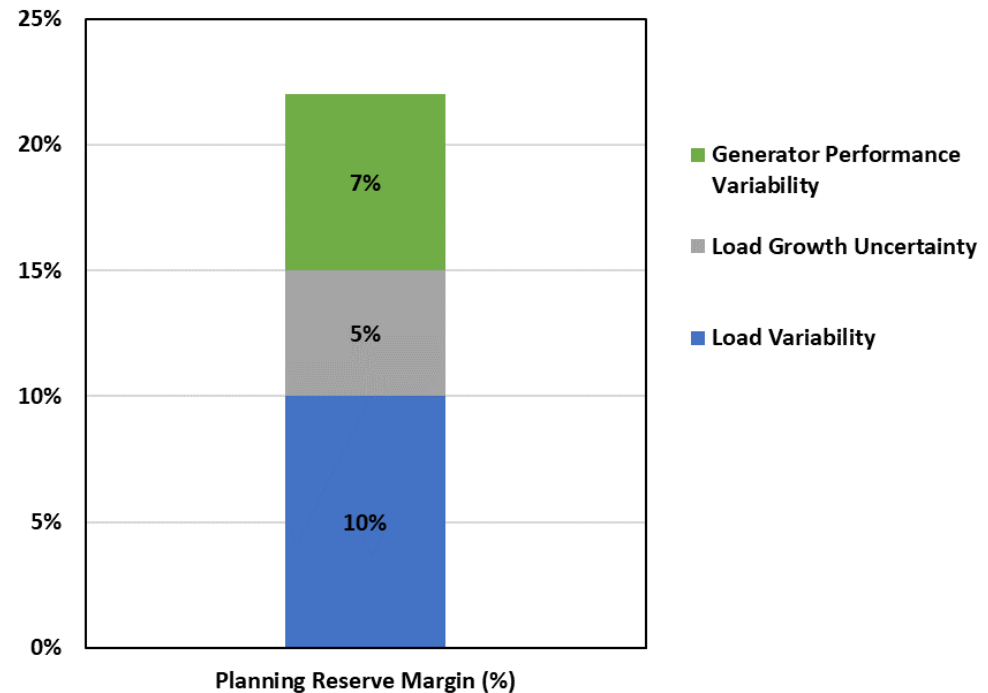
Astrapé Resource Adequacy Clients



Resource Accreditation

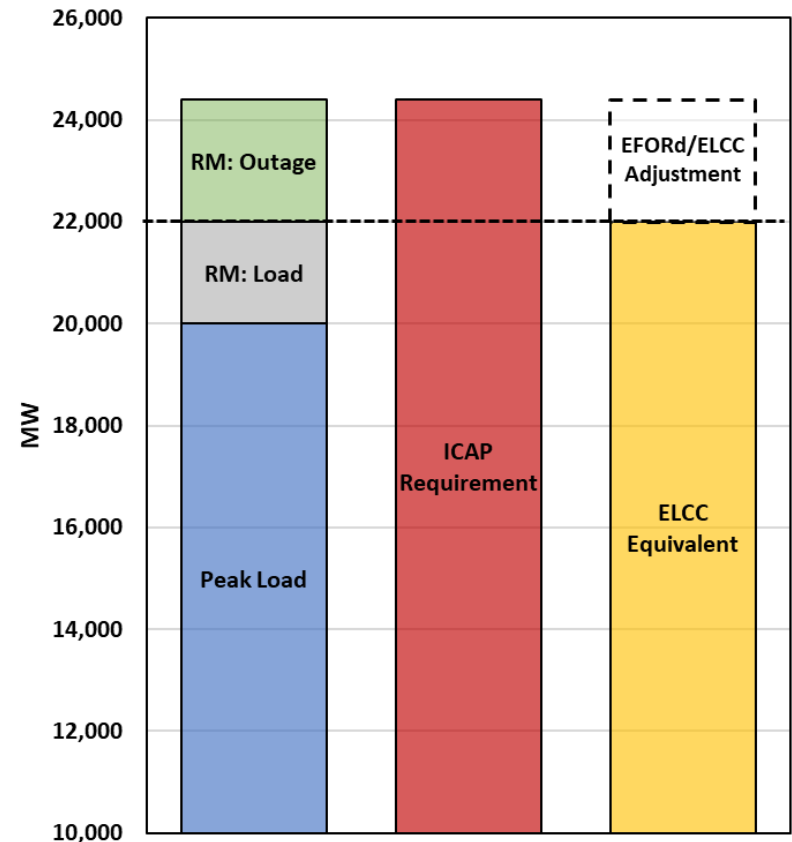
- **Planning Reserve Margin (PRM) to maintain 0.1 LOLE based on three main uncertainty factors**
 - Load variability (weather/customer usage patterns)
 - Load growth uncertainty
 - Generator outage variability
- **Disconnect: Generator performance variability included in PRM while renewable variability addressed via ELCC analysis**

ICAP Planning Reserve Margin Components (Illustrative)



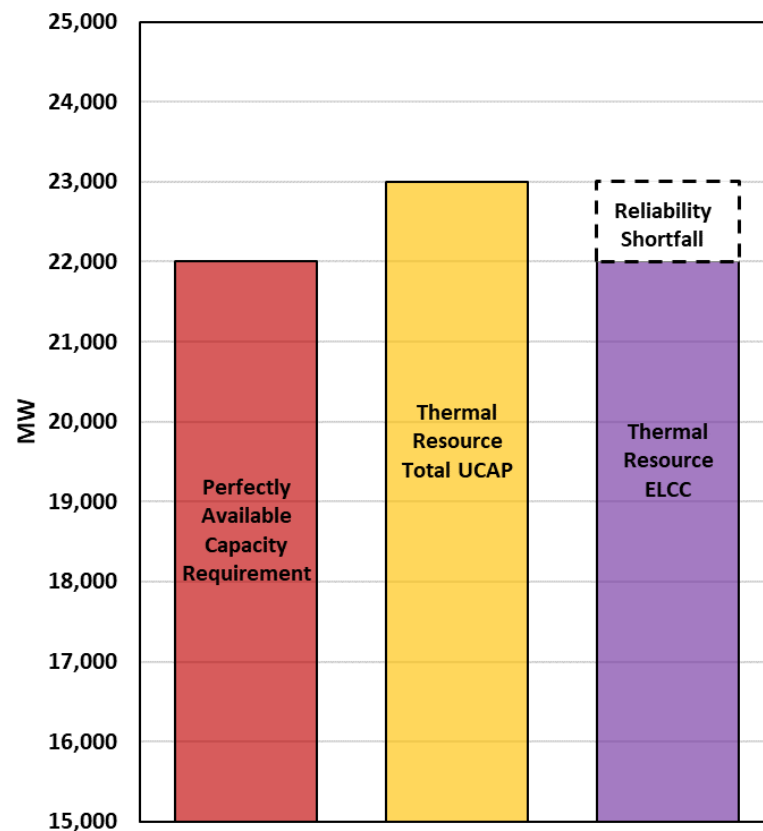
Resource Accreditation

- Under a UCAP accreditation market, resource accreditation is converted to a perfectly available capacity equivalent value
 - Thermal resources: $UCAP = ICAP * (1 - EFORD)$
 - Renewable/energy limited resources: Effective Load Carrying Capability (ELCC)
- In theory, when normalizing for perfectly available capacity, only load uncertainty drives the UCAP RM



Resource Accreditation

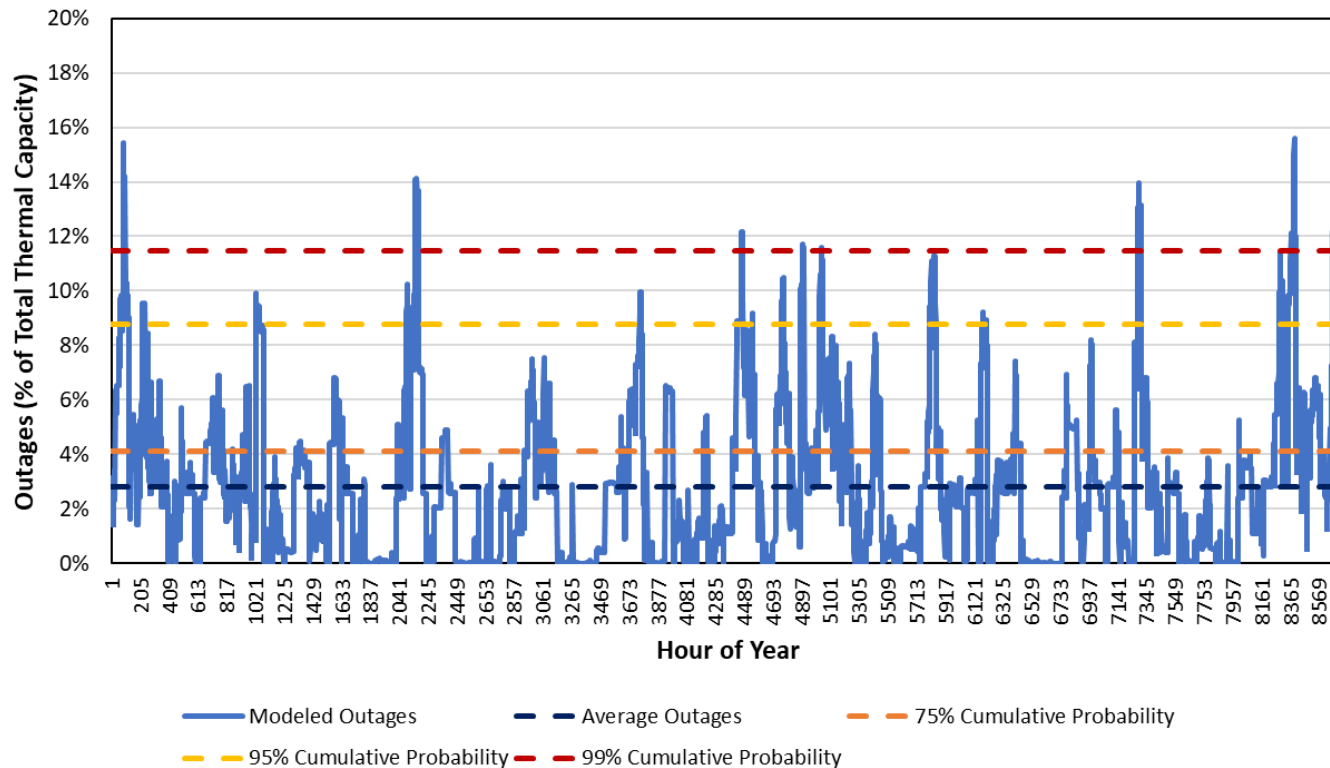
- However, UCAP accreditation may not be a good proxy for perfectly available capacity when accounting for fleet wide interactions of thermal resources
- Sum of all individual thermal resource UCAP values may be greater than the actual fleet wide contribution towards reliability (i.e., the thermal resource ELCC)
 - May or may not affect PRM
- Key fleet wide interactive outage effect categories include:
 1. Outage variability
 2. Common mode failures
 3. Weather dependent outages
 4. Fuel availability outages



Thermal Outage Impact #1: Outage Variability

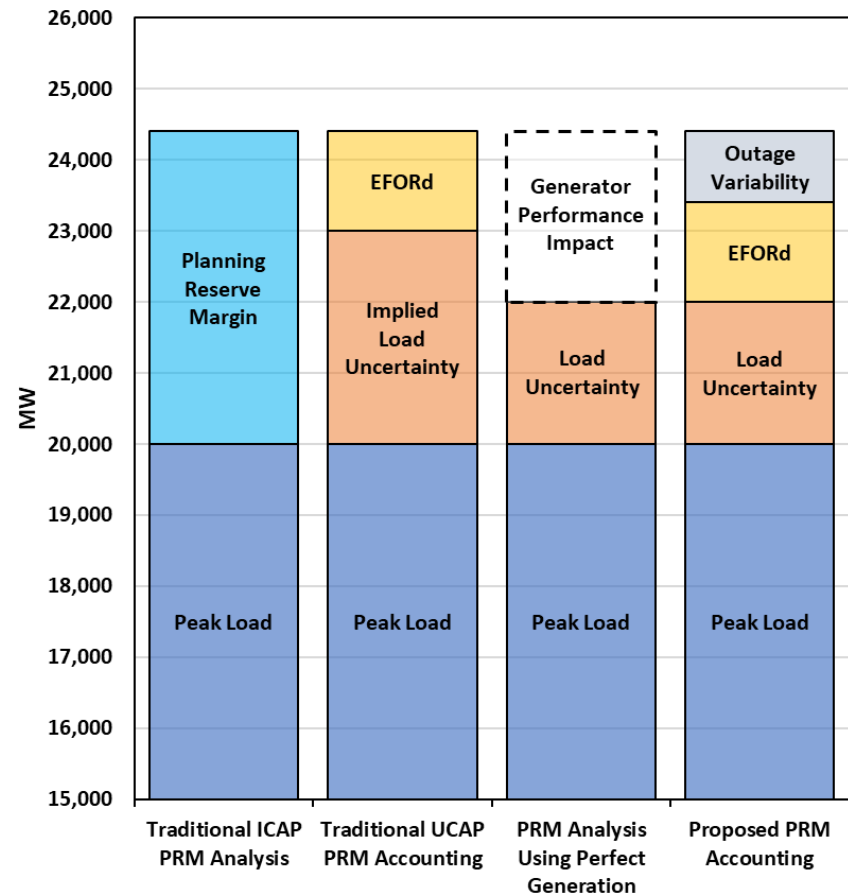
- **What level of reserves are needed to cover the impact of outages?**
 - UCAP accounting using EFORd presumes only average outages need to be addressed.

Average Outages Vs. Modeled Outages



Thermal Outage Impact #1: Outage Variability

- Outage variability is generally hidden in the PRM assessment.
- This issue would not be expected to affect PRM, only resource accreditation

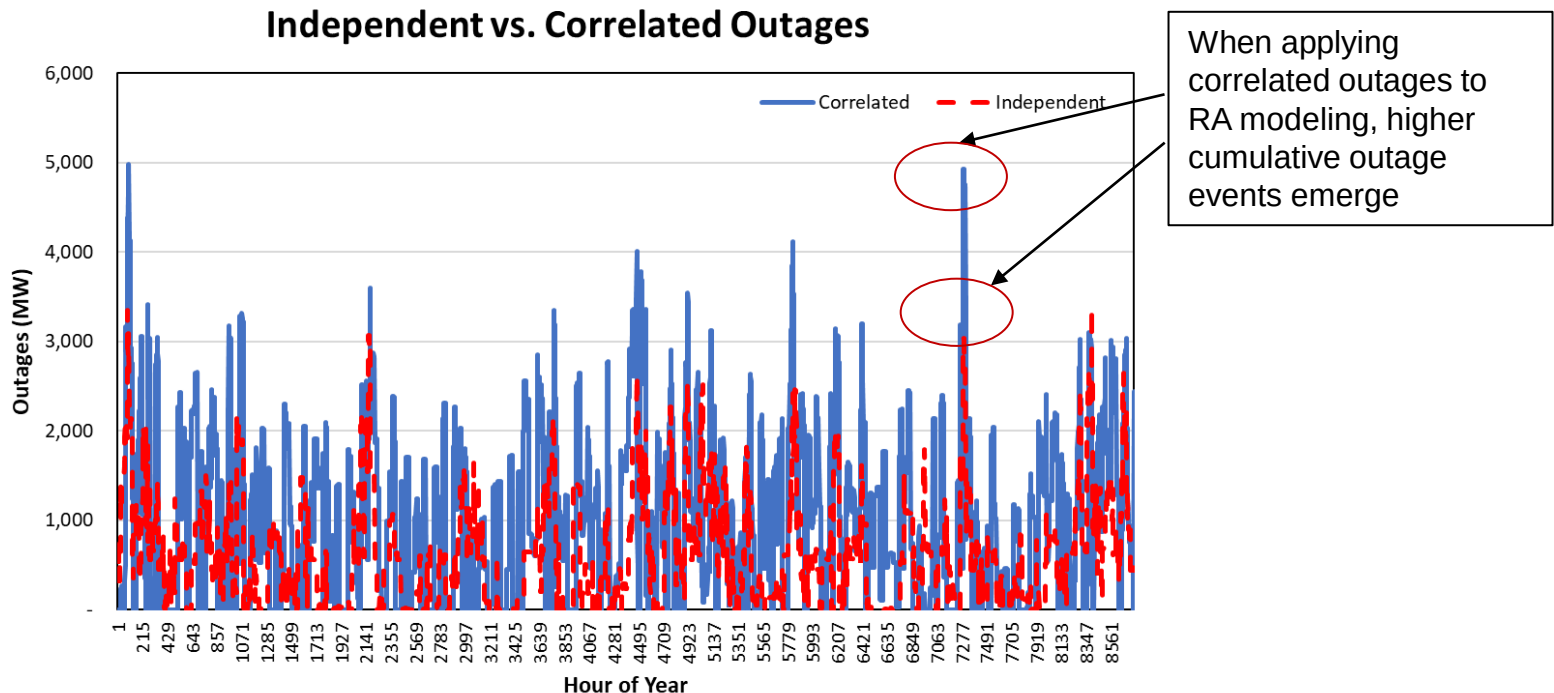


Proposed Solution for Outage Variability

- **Accreditation of conventional resources could be adjusted to properly reflect their contribution to reliability**
 - E.g., Conventional Generator $ELCC = (1 - EFORd - ADJ_{Var})$
- **Analysis suggests ADJ_{Var} could be 2.7% in the Winter and 4.6% in the Summer.**
- **Similar adjustments proposed for other correlated outage effects**

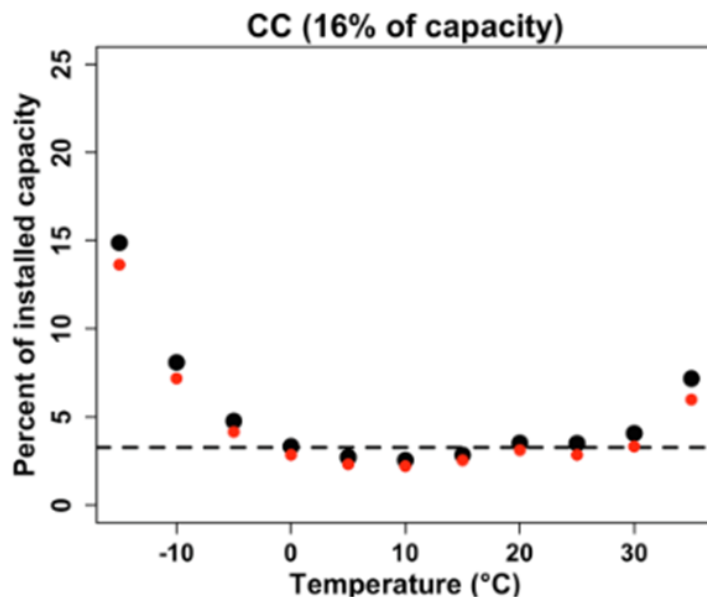
Thermal Outage Impact #2: Common Mode Failure

- Most resource adequacy modeling randomly assigns availability status for each resource independently
- In reality, outages can be correlated between resources due to common mode failures (e.g., shared step-up transformers)



Thermal Outage Impact #3: Weather Dependent Outages

- **Additional correlated outage impacts observed in historical data based on weather impacts**
 - Cold weather events: frozen lines, frozen valves, critical sensor failures
 - Hot weather events: extended run times, heat stress on components



Source: Murphy, Sinnott, et. al. "A time-dependent model of generator failures and recoveries captures correlated events and quantifies temperature dependence."

- **Example of historical PJM generator performance**

- Combined cycle outage rate as a function of median (black series) and 90% temperature observation (red series)
- At -10°C, CCs experienced ~4% higher forced outage rate than at 0°C

Thermal Outage Impact #4: Fuel Availability Outages

- **Natural gas supply constraints known to occur during cold weather**
- **As much as 10% of natural gas supply can become unavailable at temperatures of 10°F (based on review of ERCOT 2021 event, 2014 Polar Vortex, 2011 FERC report on cold weather outages)**
- **Leads to an increase in cumulative outages for specific resource classes such as CTs and CCGTs**

Modeling Summary

- Impact of incremental outages quantified as percentage adjustment factors (ADJ) to approximate the thermal resource ELCC value

- $ELCC_{Thermal\ Resource} = (1 - EFORD - ADJ)$

	Interactive Outage Effect Categories	Winter Accreditation Adjustment Factor (%)	Winter Capacity Credit ¹	Summer Accreditation Adjustment Factor (%)	Summer Capacity Credit
Standard Accounting Practice	Forced Outage Rate	5.0%	95.0%	5.0%	95.0%
Proposed Additional Considerations	Outage Variability	2.7%	92.3%	4.6%	90.4%
	Common Mode Failure Outages	2.3%	90.0%		
	Weather Dependent Outages	10.0%	82.3% ²	5.6%	84.7%
	Fuel Availability Outages ³	6.2%	76.1% ⁴		

^[1] Values shown in the Winter Capacity Credit and Summer Capacity Credit column are cumulative.

^[2] Impact calculated incremental to Outage Variability.

^[3] As studied in this analysis, Fuel Supply Outages are only applicable to natural gas units that do not have a backup supply source such as on on-site alternate fuel.

^[4] Impact calculated incremental to Weather Dependent Outages.

Questions?

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