

Correlated Outage Impact on Resource Reliability Contribution

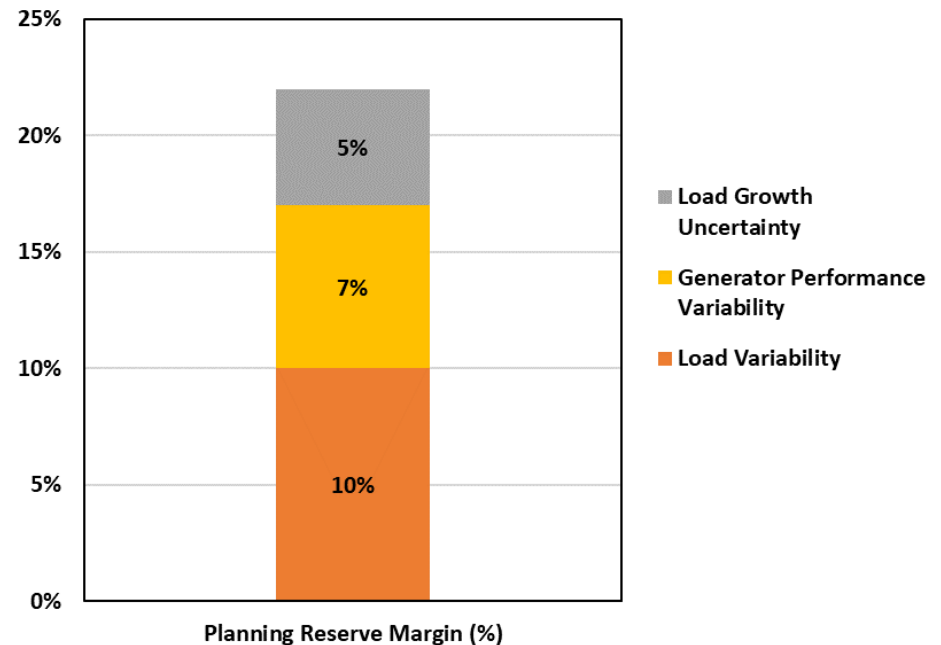
Key Work Activity #2

Kevin Carden
Astrapé Consulting LLC
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Resource Accreditation

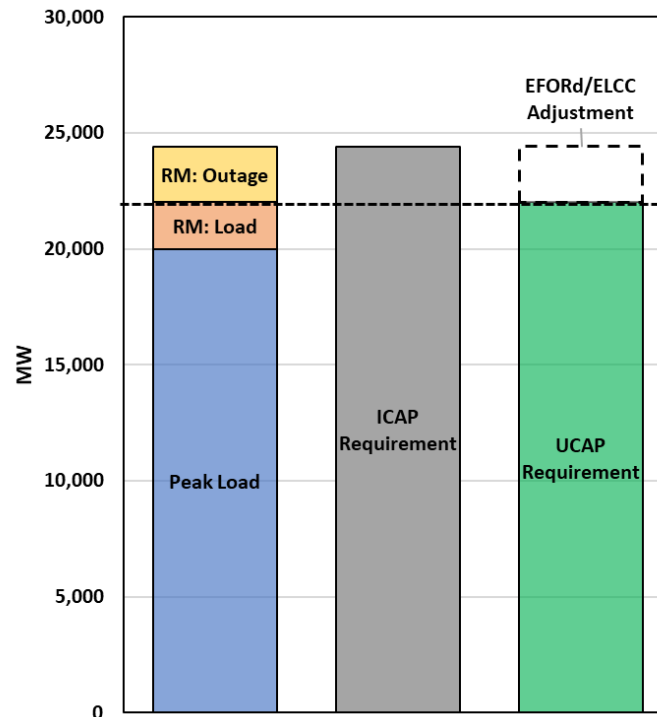
- **Planning Reserve Margin (PRM) to maintain 0.1 LOLE based on three main uncertainty factors**
 - Load variability (weather/customer usage patterns)
 - Load growth uncertainty
 - Generator outage variability
- **Disconnect: Generator performance variability included in PRM while renewable variability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

ICAP Planning Reserve Margin Components (Illustrative)



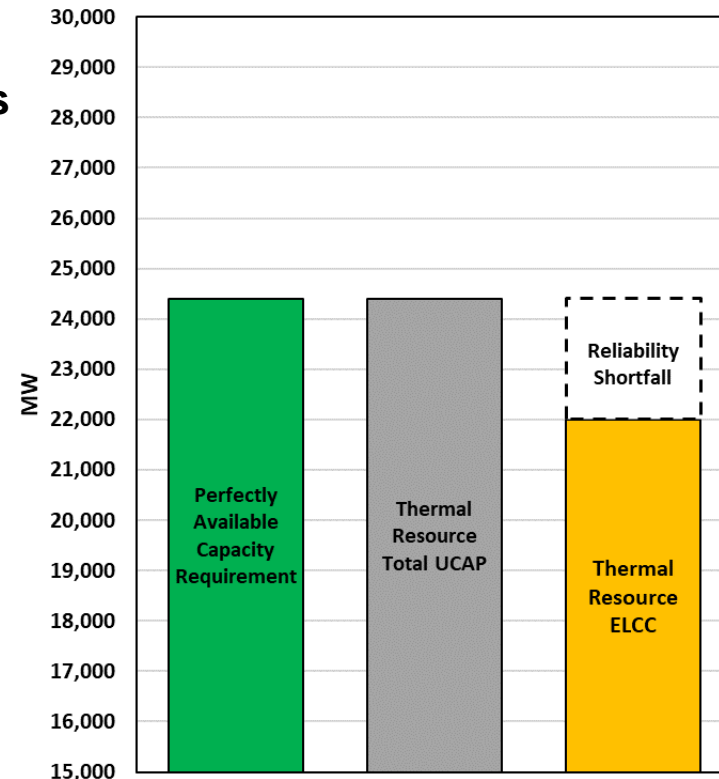
Resource Accreditation

- 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



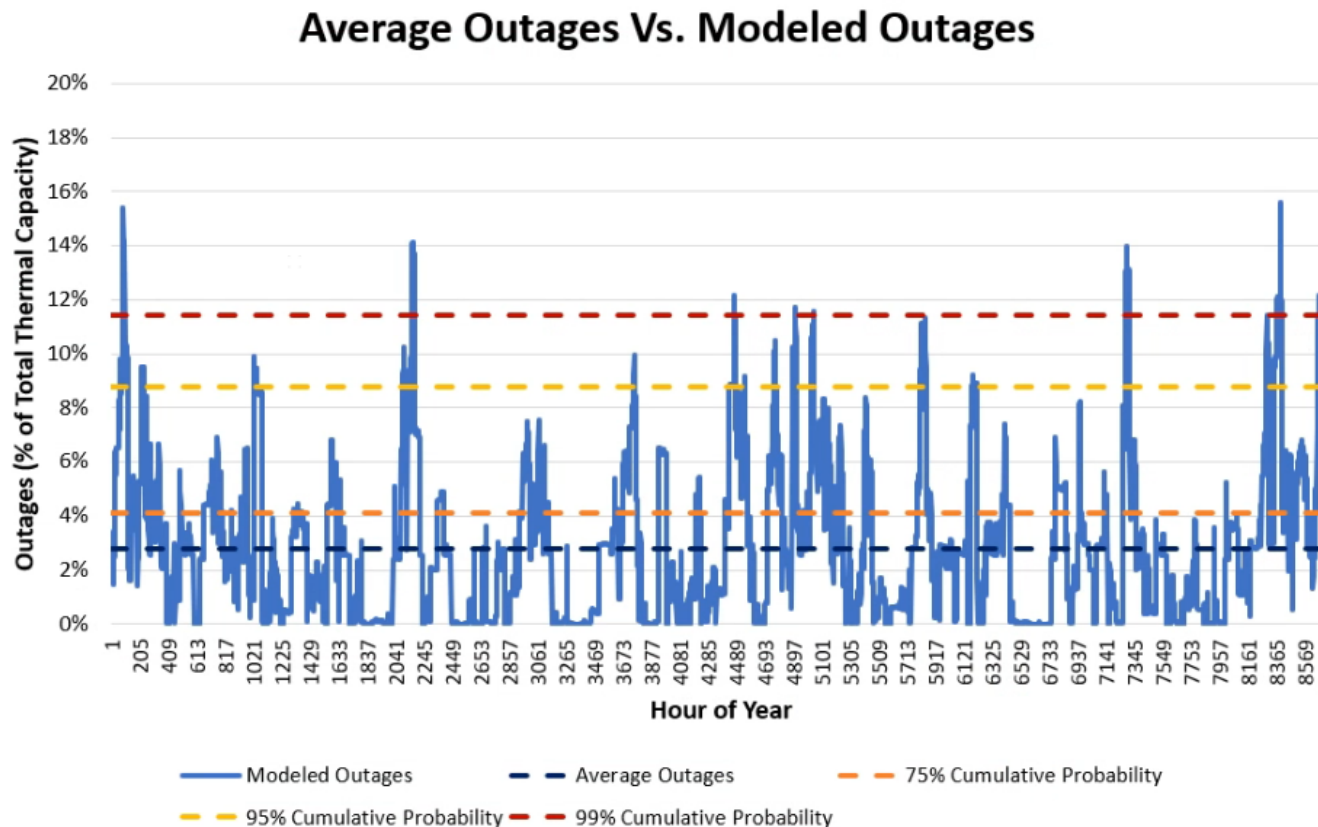
Resource Accreditation

- However, UCAP accreditation may not be a good proxy for perfectly available capacity when accounting for fleet wide phenomenon 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 correlated outage categories include:
 - Outage asymmetry
 - Common mode failures
 - Weather dependent outages
 - Fuel availability outages



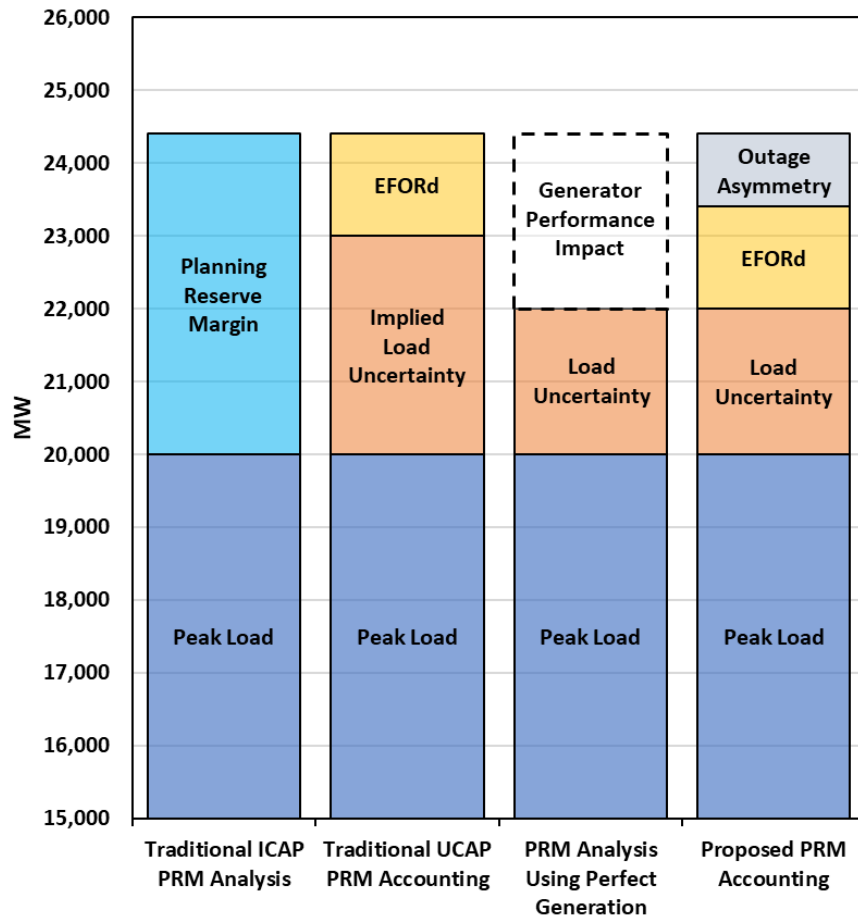
Correlated Outage Impact #1: Outage Asymmetry

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



Correlated Outage Impact #1: Outage Asymmetry

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

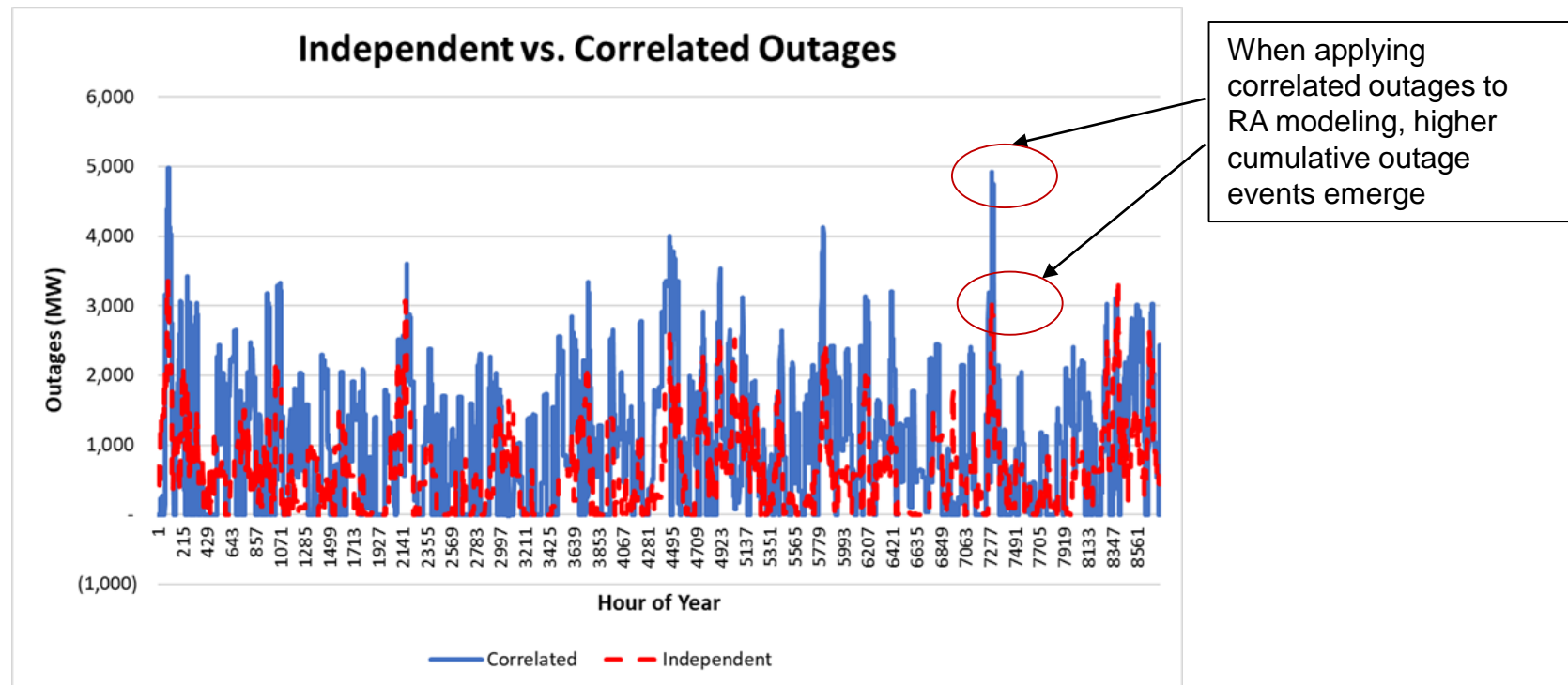


Proposed Solution for Outage Asymmetry

- **Accreditation of conventional resources could be adjusted to properly reflect their contribution to reliability**
 - E.g. Conventional Generator ELCC = $(1 - EFORd - ADJ_{Asym})$
- **Preliminary analysis suggests ADJ_{Asym} could be 2-5%.**
- **Similar adjustments proposed for other correlated outage effects.**

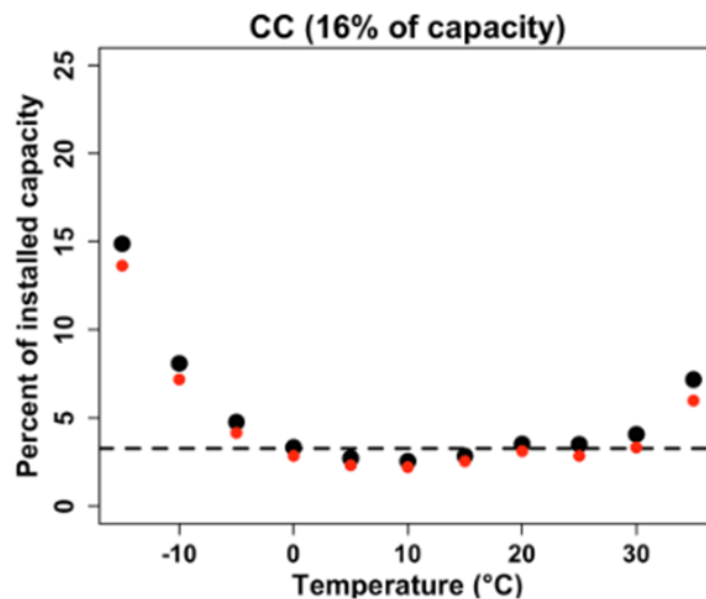
Correlated Outage Impact #2: Common Mode Failure

- 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)



Correlated 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
- **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



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

Correlated 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 0F (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 Results (Winter)

- **Impact of incremental outages quantified as percentage adjustment factors (ADJ) to approximate the thermal resource ELCC value**
 - $ELCC_{Thermal\ Resource} = (1 - EFORd - ADJ)$

Correlated Outage Category	Adjustment Factor (%)
Outage Asymmetry	2-5%
Common Mode Failure Outages	2-3%
Weather Dependent Outages	8-10%
Fuel Availability Outages	6-10%

Recommendations

- **Review historical data related to correlated outages within the PJM region**
- **Explore modeling practices to account for correlated outages**
 - Requires definition of resource classes for thermal resources, analogous to renewable/storage ELCC calculations
 - Individual resource accreditation adjustments should be considered to appropriately distribute weather/fuel outage impacts in proportion to a unit's impact on the overall resource class ELCC

Questions?

Kevin Carden

kcarden@astrape.com