PJM RESOURCE ADEQUACY METRICS AND ACCREDITATION

BACKGROUND, INTERESTS, DESIGN OPTIONS

PJM Resource Adequacy Senior Task Force (RASTF)

Key Work Activity (KWA) 2

February 28, 2022

FOCUS FOR TODAY IS THERMAL RESOURCE ACCREDITATION FOR CAPACITY MARKET PARTICIPATION

What changes to capacity market accreditation are necessary to ensure that thermal generation is capable of meeting its capacity obligations given evidence of correlated outages and other known risks that today have not been recognized in accreditation?

CONTENTS

EXISTING GAPS IN METRICS & ACCREDITATION

PJM BOARD LETTER PRIORITIZES RESOURCE METRICS AND ACCREDITATION

"…PJM is suggesting that the RASTF consider the valuation of **all resources** along with the valuation (accreditation) of resources in the context of a potential seasonal capacity product. One component of the analysis will be to **fully analyze the correlation of thermal outages** during the peak times to ensure our modeling appropriately reflects those resources' reliability contribution to the grid.

--PJM Board Letter, October 14 (Bolding added for emphasis)

For more information see "Board Response to Multiple Parties' Letter Regarding Valuation of Thermal Resources and Phase II Capacity Market Reforms", October 14, 2021. Available: https://www.pjm.com/-/media/about-pjm/who-we-are/public-disclosures/20211014-board-response-to-elcc-for-thermal.ashx
Multiple Parties' Letter, September 14, 2021. Available: https://www.pjm.com/-/media/about-pjm/who-we-are/public-disclosures/20210914-pjm-board-letter-thermal-capacity-generation.ashx

ACCREDITATION IS A CRITICAL TOPIC WITHIN RASTF KWA 2

The RASTF is seeking stakeholders interested in presenting perspectives on reliability risks and drivers (Key Work Activity #2) and/or procurement metric and level (Key Work Activity #3) at the February 28, 2022 meeting.

Speakers may consider addressing the following on reliability risks and drivers:

- Additional drivers of reliability risks that should be considered and how best to do so, or, existing ones that should be considered differently.
- The impact of seasonal differences in risk and how those should inform capacity market design.
- The drivers of risks to be considered in the capacity market and where they should be accounted for (i.e., capacity target level or accreditation level).

PJM RASTF Reliability Drivers December 17, 2021 Presentation:

- Should some supply-side uncertainties currently reflected on the demand-side of the RPM construct be addressed on the supply side of the RPM construct?
- Should the status quo modeling/quantification of these uncertainties be modified?
- What uncertainties are not listed in this presentation? Can those uncertainties be reasonably quantified?

PRESENTATION SUPPORTERS FOR PJM PRIORITIZATION OF THERMAL ACCREDITATION REVIEW UNDER KWA 2

- Cypress Creek Renewables
- Enel North America, Inc.
- Leeward Renewable Energy
- Pine Gate Renewables, LLC
- Tesla, Inc.

BACKGROUND

1. In 2021, PJM finalized reforms for solar, wind, storage, and hydro, moving to Effective Load Carrying Capability (ELCC), capturing correlated performance and outage risk in capacity accreditation

2. PJM's thermal fleet (93% of PJM's installed capacity) is treated as near-perfect and only de-rated by its unit specific EFORd. No adjustments for correlations among resource type performance

3. Fuel, weather, and other thermal outage uncertainties have been demonstrated to be correlated. What can we learn from this for thermal resource accreditation?

WITH SHIFT TO ELCC, RESOURCE TYPES ARE SUBJECT TO DISTINCT CAPACITY ACCREDITATION TECHNIQUES

	Solar, Wind, Storage, Hydro	Thermals
Portion of PJM Installed Capacity	7%	93%
Primary Input for Capacity Accreditation	Effective Load Carrying Capacity (ELCC) ELCC sensitive to 200 high-risk hours over 10+years	Equivalent Forced Outage Rate of Demand (EFORd) EFORd is calculated as taking the number of hours a unit is on full forced outage or derated hours, over the total number of service hours, over 5 years

For more information see: "EFORp & Peak Hour Period Availability (PHPA) Training", 2012. Available: https://pjm.com/~/media/training/special-events/ip-eforp/eforp-training-slides.ashx#:~:text=EFORd%20%2D%20Definition,(%20SH%20%2B%20FOH%20*%20ff%20)

CLOSING GAPS

PJM, MURPHY, & ASTRAPE ANALYSES

PJM IDENTIFIES ~4 GW THERMAL OUTAGES REFLECTED IN RESERVE REQUIREMENTS, NOT IN ACCREDITATION

	Solar, Wind, Storage, Hydro	Thermals	Thermals Impact on RTO Reliability Requirement (PJM Analysis)
Outages reflected in accreditation	• Outages and Limitations of ELCC Resources	• Random Forced Outages of Unlimited Thermal Resources	N/A
Outages reflected in reserve requirements	None	• Planned Outages of Unlimited Thermal Resources	0 MW UCAP
		• Maintenance Outages of Unlimited Thermal Resources	~1,500 MW UCAP
		• Ambient Derates of Unlimited Thermal Resources	2,000 – 2,500 MW UCAP
		• Cold Weather-Related Forced Outages of Unlimited Thermal Resources	RTO no impact; Some LDAs with winter risk increases reliability requirement

For more information see "Education: Uncertainties in PJM's Resource Adequacy Construct", December 17, 2021. Available: https://www.pjm.com/-/media/committees-groups/task-forces/rastf/2021/20211217/20211217-item-04-education-reliability-risks-and-drivers-post-meeting.ashx

MURPHY STUDY QUANTIFIES ADDITIONAL PJM THERMAL CORRELATED OUTAGE RISK

- Method: Carnegie Mellon team uses logistic regression with 23 years of availability data for 1,845 generators in PJM to model generator failures

- Findings: Temperature and load can reliably predict generator outages

ELSEVIER

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

A time-dependent model of generator failures and recoveries captures correlated events and quantifies temperature dependence

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HIGHLIGHTS

- We quantify the temperature dependence of forced outages for six generator types.
- Generator transition probabilities are modeled using logistic regression.
- Nonhomogeneous Markov models capture observed correlated generator failures.
- Resource adequacy can be improved by accounting for temperature dependence.

ARTICLE INFO

Keywords:
Resource adequacy
Generating availability data system
Correlated failures
Nonhomogeneous Markov model
Logistic regression

ABSTRACT

Most current approaches to resource adequacy modeling assume that each generator in a power system fails and recovers independently of other generators with invariant transition probabilities. This assumption has been shown to be wrong. Here we present a new statistical model that allows generator failure models to incorporate correlated failures and recoveries. In the model, transition probabilities are a function of exogenous variables; as an example we use temperature and system load. Model parameters are estimated using 23 years of data for 1845 generators in the USA's largest electricity market. We show that temperature dependencies are statistically significant in all generator types, but are most pronounced for diesel and natural gas generators at low temperatures and nuclear generators at high temperatures. Our approach yields significant improvements in predictive performance compared to current practice, suggesting that explicit models of generator transitions using jointly experienced stressors can help grid planners more precisely manage their systems.

OBSERVED OUTAGE LEVELS AT HIGH/LOW TEMPERATURES GENERALLY FAR EXCEED PJM ASSUMED LEVELS

	Assumed Outage Rate Used for Capacity Value	Observed Outage Rate @ 95 Degrees F	Observed Outage Rate @ 14 Degrees F
Combustion Turbine	3%	7%	10%
Combined Cycle	4%	7%	8%
Coal	9%	14%	12%
Nuclear	3%	13%	2%

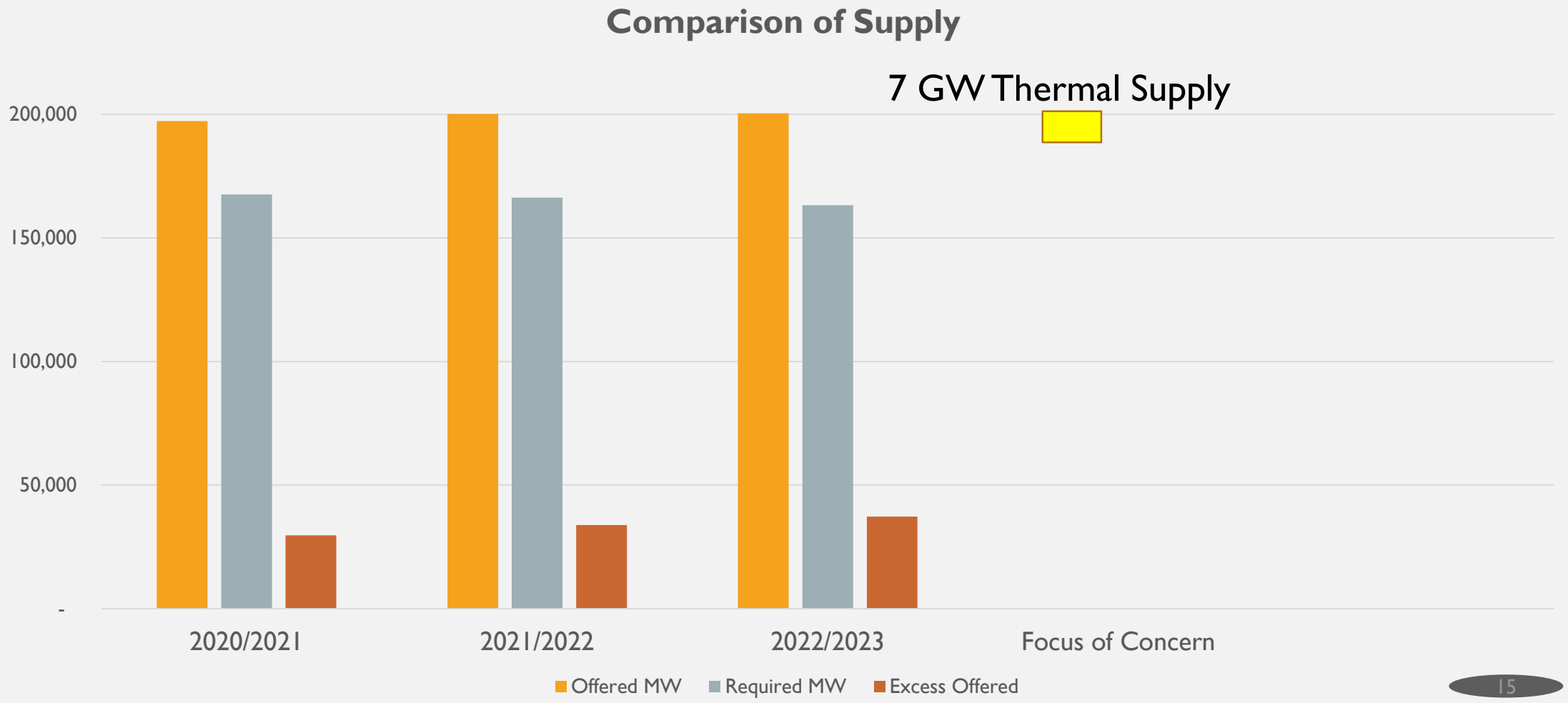
From Murphy, et al., "A Time-Dependent Model of Generator Failures and Recoveries Captures Correlated Events and Quantifies Temperature Dependencies" (2019), Figure 6. Median loads (block dots) Available: https://www.sciencedirect.com/science/article/pii/S0306261919311870

OBSERVATIONS INFER CAPACITY VALUE GENERALLY BELOW CURRENT ACCREDITATIONS

	Assumed Capacity Value	Observed Capacity Value (95 Degrees F)	Observed Capacity Value (@ 14 Degrees F)
Combustion Turbine	97%	93%	90%
Combined Cycle	96%	93%	92%
Coal	91%	86%	88%
Nuclear	97%	87%	98%

Based on Murphy, et al., "A Time-Dependent Model of Generator Failures and Recoveries Captures Correlated Events and Quantifies Temperature Dependencies" (2019), Figure 6. Median loads (block dots) Available: https://www.sciencedirect.com/science/article/pii/S0306261919311870

MURPHY STUDY INDICATES IN TOTAL, CAPACITY MARKET MAY BE PROCURING 7 GW OR MORE THAT IS UNLIKELY TO PERFORM WHEN NEEDED



RECENT ASTRAPE CONSULTING ANALYSIS IDENTIFIES FOUR CATEGORIES OF CORRELATED OUTAGES

- Outage Asymmetry
- Common Mode Failure Outages
- Weather Dependent Outages
- Fuel Availability Outages

STUDIES RAISE CRITICAL QUESTIONS FOR PJM RELIABILITY AND MARKETS

- How can we ensure that consumers are paying for resources that can **deliver** when needed?
- Is the market sending accurate price signals to appropriately **value** and **differentiate** thermal resources?
- How can markets best send exit signals to unreliable MW and entry /retention signals to **reliable** MWs?

SOLUTION OPTIONS

1. Maintain status quo disparate treatment among resource types

→ No actions. However, unsustainable threats to reliability, markets

2. Remove correlated risks from accreditation for all resources

→ Return to pre-ELCC

3. Account for correlated risks for ALL resources in accreditation

→ Develop adjustments to EFORd (Astrape study)

CONCLUSION

INTERESTS AND DESIGN OPTIONS

CONCLUSION

1. Correlated outage risk **exists** among thermals and may be growing given shifts in supply mix
2. Correlated outage risk **is** addressed in ELCC resource accreditation, but **not** under thermal accreditation (EFORd)
3. **Load** bears the risk for correlated outage risk for thermals, while **suppliers** bear the risk for ELCC resources
4. **PJM analysis** identifies 4 GW in reliability requirements from outages not accounted for in thermal accreditation today (Maintenance Outages, Ambient Derates)
5. **Murphy and Astrape** analyses quantify additional PJM thermal risk from Outage Asymmetry, Common Mode Failure, Weather Dependent Outages, and Fuel Availability Outages
6. **Solution Options** – Astrape study offers tools to align resource accreditation for all under ELCC

KWA 2: INTERESTS

- Maintain reliability through the changing resource mix
- To the extent uncertainty is accounted for on the supply side via capacity accreditation for some resources, all generation resources should be treated the same
- Differentiate reliability value of capacity resources through accreditation
- Differentiate reliability value on a resource-class basis and unit-specific basic
- Support accurate price signals for market entry/exit among all technology types
- Reasonable PJM workload on implementation
- Reasonably transparent process to identify resource values
- Maintain a reasonable look ahead period and procedure
- Account for existing and new thermal technologies
- Discuss impacts on CIR retention over time

KWA 2: DESIGN OPTIONS

- Additions:
  - Types of thermal correlated outage risk with definitions, where reflected in RPM, modeling and scale of impact on reliability requirement / UCAP:
    - Outage Asymmetry of Unlimited Resources
    - Common Mode Failure of Unlimited Resources
    - Hot Weather Dependent Outages of Unlimited Resources
    - Fuel Availability Outages of Unlimited Resources

- Already identified in the Matrix and include:
  - Cold Weather Dependent Outages of Unlimited Resources
  - Maintenance Outages
  - Ambient Derates

NEXT STEPS

1. Under KWA 2, PJM and stakeholders should speedily analyze the problems identified further and evaluate reform options, leveraging **PJM, Murphy and Astrape** analyses

2. Timeliness is critical to return to **parity** in resource treatment and maintain **reliability**

CONTACT INFORMATION

Thank you for your attention. Please share your feedback.

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