Electric transmission operators could benefit from temperature-dependent resource adequacy modeling

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How much does a power system's reliability depend on the temperature? Electric power system generator resource adequacy modeling is designed to help determine capacity requirements for electric power system operators across the United States. While calculating resource adequacy requirements has been done for a century, it requires ongoing attention as the generation mix is constantly expanding and changing. A new paper contributes to these ongoing reliability considerations by using a unique data set to determine how both low and high temperatures reduce the reliability of coal, gas, diesel, hydroelectric, and nuclear power generators and thus affect the amount of generation markets should contract for.

The paper, "Resource Adequacy Implications of Temperature-dependent Electric Generator Availability," by researchers at Carnegie Mellon University, was published in *Applied Energy*.

"Our focus is on better understanding the determinants of generator availability and incorporating these considerations into resource adequacy modeling," says Jay Apt, a Professor and Co-Director of the Carnegie Mellon Electricity Industry Center, who co-authored the paper. "Ultimately, this could improve a system operator's ability to determine how much generation is needed when the temperature is very cold or very hot."

The researchers evaluated the PJM Interconnection, the largest electric transmission system operator by installed generation capacity and load in North America, by making use of observed temperature-dependent forced outage rates over 25 years. Current grid resource adequacy modeling assumes that generator failures are unrelated to temperature, though this presents substantial resource adequacy risk. For example, in PJM's case, extreme weather events such as the Polar Vortex cold snap of 2014 added significant stress to the electric grid, suggesting that contrary to prevailing assumptions, generator failures are correlated. Further, assuming unconditional independence can lead to underestimating power system capacity requirements.

The researchers first determined that extreme temperatures, both hot and cold, resulted in less output from PJM's fleet. They then computed capacity requirements for PJM in two different scenarios for a 12-month period in 2018 and 2019. The first represented current practices wherein unconditional independence is assumed, and the second allowed for generator availability to depend on temperature. Additionally, they explored how accelerating changes to the resource mix (i.e.; moving from fossil fuels to solar and wind energy) and future temperature increases under climate change may affect resource adequacy at PJM.

Given the strong seasonality of extreme temperatures, the researchers considered whether monthly procurement targets would help PJM reduce capacity requirements as opposed to the current annual procurement model. They observed the accumulated loss of load expectation (LOLE)—the probability of a blackout due to insufficient power generation—during each calendar month under an annual procurement approach, using both unconditional and temperature-dependent forced outage rates. After accounting for temperature dependence of generator availability, they determined that monthly capacity procurement targets would substantially reduce annual average reserve procurement in PJM with negligible effect on LOLE. This, they explained, is because spring and fall months experience mild temperatures, leading to both lower loads and increased generator availability.

Ultimately, this analysis demonstrates the importance of considering temperature-dependent conditions in resource adequacy modeling. The sort of monthly or seasonal capacity procurement the authors propose could reduce PJM's reserve margin from the 26.6% reserve margin PJM procured in 2018-19 to 22.9%, representing a $315 million annual economic benefit. The authors note that further research is needed to account for the risk of lost load from generator outages during sustained extreme weather events, incorporate demand response resources, quantify operational flexibility needs, and allow system operators to better understand the value of procuring operating reserves.

More information: Sinnott Murphy et al, Resource adequacy implications of temperature-dependent electric generator availability, *Applied Energy* (2020). DOI: 10.1016/j.apenergy.2019.114424

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