Reliability Insights

New Approaches Needed to Ensure System Adequacy

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Traditional Resource Adequacy Methods Are No Longer Enough

Nearly 400 million North Americans depend on an *adequate* and reliable supply of continuous electrical energy that is supplied by an electric grid increasingly reliant on weather-dependent and just-in-time fuel resources. *Ensuring* reliability is made more challenging by increasing uncertainty in future supply and demand, especially with high load growth. Overcoming these challenges through system planning and operations is key to ensuring energy *adequacy*. *Adequacy*, as it relates to the grid, is traditionally measured by whether capacity can meet peak demand; however, this approach, which is focused on capacity-based reserve margins and deterministic planning, is no longer sufficient by itself.

Industry and policymakers must guide a transition from a *capacity*-based approach to an *energy*-based one. This transition entails modernizing planning practices; investing in and retaining flexible and secure fuel resources that are less than firm; and supporting standardized, probabilistic approaches with scenario-based assessments that properly reflect the realities of today's evolving resource mix that has vastly different reliability attributes.

Recent system events show that capacity alone does not guarantee a reliable and secure source of energy, and failure to act can result in greater risk. The consequences are growing—larger outages, economic disruption, and impacts on public health and safety. As demand growth projections have reached heights not seen in decades, the time is right to enhance resource and transmission planning processes.

Applying Past Learning to Future Planning

Today's grid faces higher volatility, lower predictability, and more severe consequences when things go wrong. Simply maintaining reserve margins may give a false sense of security as evidenced during several recent, significant events:

- **Texas (Winter Storm Uri, 2021):** At the time of this event, the ERCOT area was considered "resource adequate" by the targets set by ERCOT and the Public Utility Commission of Texas, but extreme cold disrupted gas supply and froze generation of all types. Up to 20,000 MW of emergency firm load shed was required over multiple days due to extreme demand, low renewable output, and a huge amount of thermal generation forced off-line.
- **Midwest (June 2023):** More than 60,000 MW of wind capacity dropped to 300 MW during a widespread low-wind event also known as a dunkelflaute (see **Figure 1**). Fortunately, the system was lightly loaded for spring conditions, and excess generation from the area and

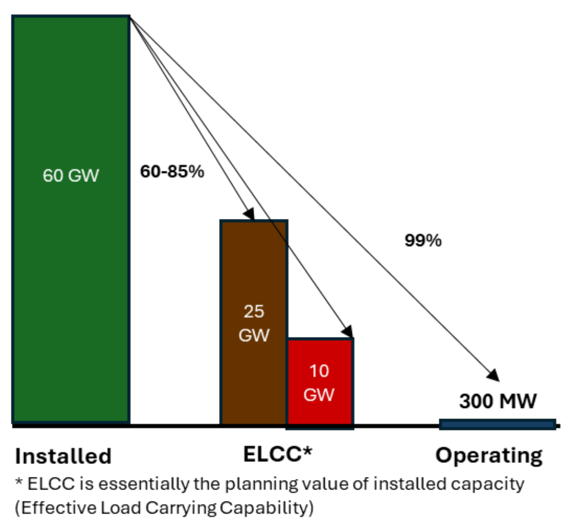


Figure 1: June 6, 2023, Wind Production North American Mid Continent

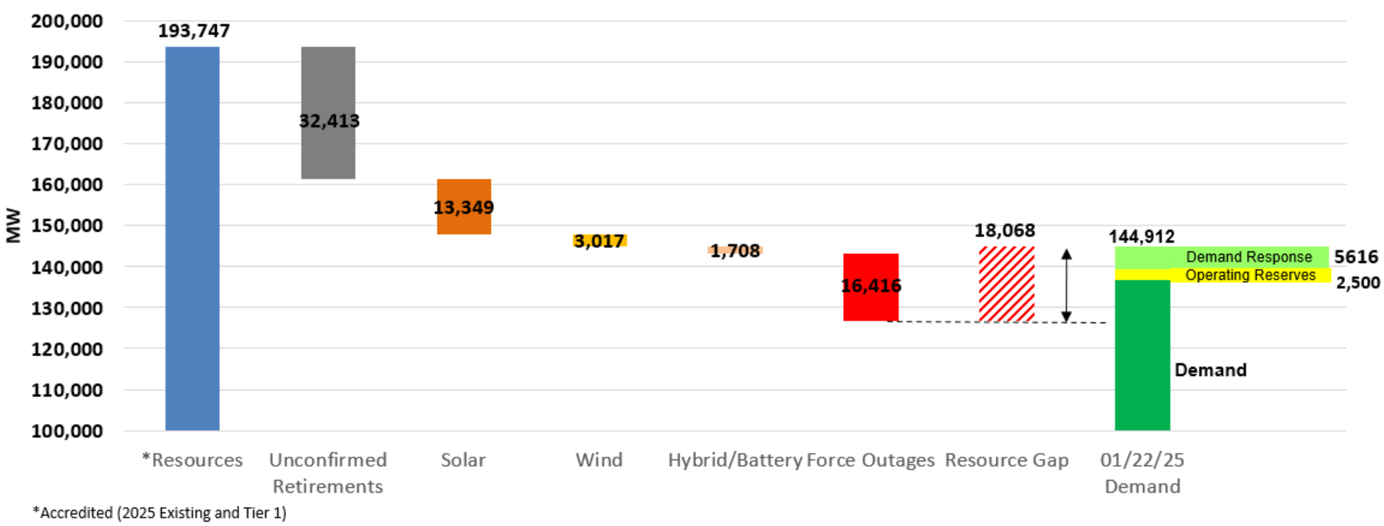
neighbors was able to support the sudden loss of generation. Had the low-wind conditions occurred during summer or winter peak conditions, the system would have been significantly deficient in energy.

These events show that using capacity values alone does not guarantee a reliable and adequate source of energy.

Winter Energy Adequacy Brings New Challenges

Severe winter weather events in 2021 and 2022 provided stark evidence of the critical nature of natural gas as a generator fuel and the importance of secure fuel supplies during times of extreme electricity demand. For solar resources during the early-morning hours, the on-peak contribution is essentially zero. While the solar + battery energy storage solutions are effective at supporting summer peak demand, winter energy adequacy remains highly dependent on the reliability of the natural gas system—which has recently struggled to provide non-firm deliveries to power plants in addition to firm deliveries to other gas customers.

A ReliabilityFirst (RF) analysis shows how various constraints and the uncertainty of future resource retirements can significantly impact winter peak conditions and reduce the availability of capacity already on-line. Looking at a future year (Winter of 2029/2030), RF shows in **Figure 2** operational conditions similar to what occurred during Winter Storm Enzo in January 2025. By Winter 2029, just over 161 GW of available generation resources can be assumed to be in service (193 GW minus 32 GW of unconfirmed retirements). If wind, solar, and battery output is marginal, as stated earlier, and 32 GW of unconfirmed retirements were factored in, there could potentially be a 20 GW resource deficit when considering the operational conditions observed during January 2025. Both tighter conditions and dependence on optimal weather conditions are increasing the risk profile during the coldest days of the year.



https://www.nerc.com/pa/RAPA/ra/Reliability Assessments DL/Evolving_Planning_Criteria_for_a_Sustainable_Power_Grid.pdf **Figure 2: PJM 2029/30 Winter Risk Scenario (using Jan 2025 Peak Conditions)**

Opportunities to Ensure Energy Adequacy

NERC is encouraged by changes underway in some regions to address these identified risks during this era of growth and grid transformation. To maximize effectiveness, market mechanisms used to procure resources must align with energy risks that are present today and will intensify in the future. This shift to providing energy adequacy should involve these key principles:

- **Probabilistic and scenario-based risk assessment:** Energy must be available during all hours and seasons and under stress conditions, such as extreme weather or fuel supply interruptions. Market operators will need to effectively assess the risk of energy shortfalls; doing so will require probabilistic studies and risk scenario analysis and make use of energy metrics and criteria, such as those identified in the NERC-National Academy of Engineering workshop report, *Evolving Planning Criteria for a Sustainable Power Grid*. Modernizing resource adequacy criteria by supplementing it with energy-based metrics is an important component that states and provinces should consider as part of their regulatory obligations. Recent enhancements in Texas highlight the value that these metrics bring to representing potential resource deficiencies.
- **Risk-informed market procurement:** Procuring resources for a fixed reserve margin target in a single peak season falls short of providing assurance that energy needs throughout the year are adequately addressed. Informed by probabilistic risk assessments, markets must appropriately procure resources to address identified risks. Clear signals that account for all critical periods are needed to ensure markets are aligned with reliability objectives, and mechanisms to strengthen energy availability may be needed. Intrinsic to this is the need to value the contribution of energy-limited resources during the risk periods. Further, ensuring that incentives are in place so that generating resources are ready to withstand projected extreme weather events and firm up fuel supplies may require Reliability Standards and/or market reform.
- **Value all required reliability attributes:** To ensure that the future resource mix can provide essential reliability services (e.g., ramping, frequency and frequency response, voltage support) to the grid and allow the flexibility that operators need to balance supply and demand in real time, procurement mechanisms need to value reliability attributes correctly. Innovative products to ensure resources for frequency response and flexible ramping capability are needed. Fuel assurance should be valued in the market when fuel supply risks could threaten reliability, especially in winter.
- **Set an agreed design basis for the future grid:** Historically, the grid has been planned to a 1-event-in-10-years standard. This was appropriate when the generator fleet consisted of assets with well-known and understood outage and availability risks. Today, much deeper insight into both capacity availability and fuel supply risks is needed, as well as a better understanding of the frequency, duration, and scale of events. This will require stronger modeling of fuel and capacity performance to assess reliability risk. The industry should align around a common set of “design basis” parameters.

Conclusion

Assuring an adequate supply of electricity now and in the future requires modernized planning approaches that are focused on energy. A new design basis is needed that reflects the contemporary risks to the changing generation resource mix and transforming grid, such as disruptions to fuel supplies, wind and solar droughts, and extreme weather. This new construct must also consider how energy needs are being shaped by the electrification of the economy, including the transportation and heating sectors.