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INSIGHT

Electric Reliability and Power System Resilience

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Electricity is vital to the commerce and daily functioning of the United States. Nowhere has this been demonstrated more significantly than in Puerto Rico and the U.S. Virgin Islands where the effects of the widespread loss of electricity after Hurricane Maria are still being felt. Subsequently, there has been much discussion about electric system reliability, and how electric systems can improve resiliency. And while the effects were not as catastrophic, the impacts of the Bomb Cyclone in January 2018 caused some to question whether the increasing retirements of coal and nuclear power plants could lessen fuel diversity and affect electric power system resilience.

While electric system reliability and system resiliency are related, they differ both in scope and regulatory requirement. Reliability, according to the U.S. Department of Energy (DOE), is the ability of the system or its components to withstand instability, uncontrolled events, cascading failures, or unanticipated loss of system components. Resilience, as defined by DOE, is the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions.

Mandatory and Enforceable Rules for Reliability

Congress gave the Federal Energy Regulatory Commission (FERC) authority to oversee the reliability of the bulk-power system under the Energy Policy Act of 2005 (P.L. 109-58; EPACT05). Reliability standards were added as Section 215 of the Federal Power Act (FPA) to help ensure the reliable operation of the bulk power system so that "instability, uncontrolled separation, or cascading failures" will not occur as a result of a sudden disturbance. Section 215 of the FPA also defines FERC's jurisdiction in terms of "users, owners, and operators" of the bulk power system. FERC can approve or remand back reliability standards proposed by the Electric Reliability Organization, which bulk-power system owners and operators must follow to help ensure the reliable operation of the grid. Reliability standards address programs ranging from vegetation clearances in electric transmission line rights-of-way, to policies and procedures for critical infrastructure protection focused on the cyber- and physical security of power plants and supporting facilities. The standards are both mandatory and enforceable in that violators of reliability rules may be subject to a civil fine of up to $1,000,000 per violation for each day that it continues. However, Commission-approved reliability standards are only applicable to the continental United States, and not to U.S. territories such as Puerto Rico.

Additionally, DOE's Office of Electricity Delivery and Energy Reliability has responsibility for the security and reliability of critical energy infrastructure (not just electricity) in emergency situations.

In the United States, there are two main indices used to measure reliability. The system average interruption duration index (SAIDI) represents *the average amount of time per year that power supply to a customer is interrupted*, expressed in minutes per customer per year. The system average interruption frequency index (SAIFI) represents *the average number of times per year that the supply to a customer is interrupted*, expressed as interruptions per customer per year. However, there is a lack of consistency in how the inputs to these indices are measured, since some jurisdictions consider storm-related outages as "extreme" or unusual events, and thus do not include these in power outage statistics.

Resilience Must Be Planned

According to the DOE, there are no commonly used metrics for measuring grid resilience. Electric system resilience is not mandated by federal law, but the ability of the system to adapt to changing conditions and recover rapidly from disruptions is a key attribute of electric system reliability. A 2016 report from several of DOE's national laboratories focused on this changing environment, and the need to maintain a resilient power system. The report identified risks ranging from weather events that disrupt transmission or distribution, to high impact, low frequency (HILF) risks such as catastrophic hurricanes. The report also built upon previous developments identified by DOE in the energy sector including growing potential threats from climate change, energy security, transitions from coal to natural gas generation, increased deployment of distributed and renewable generation, and rising investments to modernize the energy grid. While the report acknowledged that electric power systems "are currently well-equipped to effectively manage a broad range of threats," it recognized that some risks remain challenging and that "resilience efforts should shift toward these more complex risk management challenges." Some of the key risks to resilience identified include

- HILF threats associated with natural hazards (particularly weather or space weather) of historic intensity or large-scale physical, cyber, or electromagnetic attacks.
- Combined or blended threats associated with simultaneous exposure of the electric grid to one or more natural threats in combination with a physical or cyberattack.
- Threats that affect vulnerable components of the electricity system or that exceed critical thresholds. For example, distribution networks are often a weak link in the electric grid, but disruptions and outages associated with distribution are often localized.

The report provided a number of recommendations "to guide future decision-making to enhance resilience of the U.S. electricity system." These recommendations included

- Build a greater understanding of HILF events and capability to incorporate HILF threats into risk assessment. Scenario-based planning to explore multiple contingencies can be used to stress test the system and identify gaps in resilience.
- Develop a robust and scalable system of resilience metrics for the electricity system.
- Increase their capacity to assess and manage risks and their uncertainties which may change over time and geographic areas. Future changes in not only the climate, but also population, technology, and societal preferences have important implications for resilience.
- Institute policies and practices that can help to streamline assessment and decisionmaking while enhancing coordination and communication can be just as important to resilience as the development of robust infrastructure and assets.

How electric power systems incorporate resiliency into reliability planning will depend on the evaluation of risk to the system, and the financial and other resources available to system planners. Given the potential consequences of long-term electric power failures, Congress may consider further how various electric power systems incorporate resilience in reliability planning.

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