ACCCE
AMERICA'S POWER

Grid Resilience

A secure electricity supply is vital to the nation's economy, safety, and well-being. This means ensuring that the bulk power system — power generation facilities and the high-voltage transmission system — is both reliable and resilient.[1] The purpose of this paper is to briefly explain the differences between reliability and resilience, and why resilience is becoming increasingly important because of changes to the electric grid, especially the retirement of coal and nuclear power plants.

Reliability and resilience are not the same thing. While reliability and resilience are often conflated or treated synonymously, they are not the same. For example, the recent National Academy of Sciences (NAS) report, *Enhancing the Resilience of the Nation's Electricity System*, says simply that "reliability and resilience are not the same thing." NAS goes on to point out that "for decades, the planners and operators of the system have taken care to assure that [it] is engineered and routinely operated to achieve high levels of reliability. Increasingly, the system's planners and operators are focusing on *resilience* as well."[2] (Emphasis added)

Reliability is a well-defined term with agreed upon metrics. The North American Electric Reliability Corporation (NERC) defines a reliable bulk-power system as one "that is able to meet the electricity needs of end-use customers, even when unexpected equipment failures or other factors reduce the amount of available electricity." NERC divides reliability into two categories:

- Adequacy — having sufficient resources to provide customers with a continuous supply of electricity at the proper voltage and frequency, virtually all the time; and
- Security — the ability of the bulk power system to withstand sudden disturbances, while avoiding uncontrolled cascading blackouts.[3]

NAS indicates that "reliability metrics are relatively mature and in widespread use."[4] According to NERC, metrics for resource adequacy[5] range from simple calculations of planning reserve margins to more sophisticated studies that predict ten-year loss of load expectation (LOLE) values. The LOLE planning criterion requires that sufficient capacity be maintained so that peak load does not exceed supply more than once in ten years.[6]

Many analysts have developed lists of reliability attributes (e.g., voltage control, frequency response) and scorecards that rate various generating resources against those attributes. However, reliability metrics do not generally provide information about resilience.

In contrast to reliability, there are no agreed upon resilience criteria or metrics. Definitions of resilience by different groups tend to be consistent. PJM states that resilience is "preparing for, operating through and recovering from a high-impact, low-frequency event. Resilience is remaining reliable even during these events."[7] According to NAS, resilience is "not just about being able to lessen the likelihood that outages will occur, but also managing and coping with outage events as they occur to lessen their impacts, regrouping quickly and efficiently once an event ends …."[8]

However, there are no agreed upon resilience criteria or metrics. According to PJM, "[C]riteria for resilience are not explicitly defined or quantified today."[9] Likewise, the NAS report indicates that "unlike reliability, there are no generally agreed upon resilience metrics that are used widely today."[10]

The NAS does point out resilience metrics that have been proposed in a few recent studies. For example, the DOE-supported Grid Modernization Laboratory Consortium proposed a number of resilience metrics, including cumulative customer-hours of outages, time to recovery, and cost of recovery.[11] NAS recommends that DOE, FERC, NARUC, NERC, and others assess the numerous proposed resilience metrics.[12] And the recent DOE report recommends that "NERC should consider adding resilience components to its mission statement … RTOs and ISOs should further define criteria for resilience, identify how to include resilience in business practices, and examine resilience-related impacts of their resource mix."[13]

Fuel security is critical to both reliability and resilience. According to DOE, "Fuel assurance is a growing consideration for the electricity system. Maintaining onsite fuel resources is one way to improve fuel assurance."[14] The NAS report recommends that "fuel diversity, dual fuel capability, and local storage should explicitly be addressed as a part of these resilience strategies."[15] Both reports refer to the coal fleet's on-site fuel supply that contributes to grid resilience. For example, over the past five years, the coal fleet has maintained an average onsite stockpile of 73 days of subbituminous coal and 82 days of bituminous coal.[16]

DOE's Grid Resiliency Pricing Rule is a major step to improve grid resilience and prevent premature coal retirements. Recently, DOE announced a proposed rule that recognizes:

- There have been significant retirements of fuel-secure generation;
- Regulated wholesale power markets are not adequately pricing resiliency attributes of fuel-secure power; and
- DOE's staff report makes clear there are challenges to the grid and resiliency must be addressed.[17]

DOE has proposed that FERC issue a rule requiring the organized wholesale electricity markets (RTOs/ISOs) to adopt changes to "ensure that the reliability and resiliency attributes of generation with on-site fuel supplied are fully valued." Because of the importance of resilience, DOE has established a 105-day schedule for grid operators to make changes to their market rules.

October 1, 2017

[1] This paper does not address reliability issues on the electric distribution system.
[2] NAS Report at 1-3.
[3] NERC, "Frequently Asked Questions," August 2013.
[4] NAS Report at 2-26.
[5] Resource adequacy means ensuring there is adequate generating capacity to meet peak projected electricity demand.
[6] NERC, 2016 Long-Term Reliability Assessment, December 2016.
[7] PJM Interconnection, *PJM's Evolving Resource Mix and System Reliability*, March 30, 2017. ("PJM Report")
[8] NAS report at 1-4.
[9] PJM Report at 39.
[10] NAS Report at 2-28.
[11] NAS Report at 2-29.
[12] NAS Report at 2-32.
[13] DOE report at 126.
[14] DOE Report at 11. The DOE report mentions frozen coal piles during the 2014 Polar Vortex. However, NERC's review of the incident shows that natural gas represented over 55% of outages during the event, compared to 26% for coal. (NERC, *Polar Vortex Review*, September 2014)
[15] NAS Report at 4-22.
[16] EIA, *Electricity Monthly Update*, accessed July 27, 2017. This is the average amount of coal stockpiled over the past five years. Plants that use bituminous coal have an average stockpile equivalent to 82 days of coal use; plants burning subbituminous coal average 73 days.
[17] DOE Proposal.