"Ensuring Reliability and Resilience — A Case Study for the PJM Power Grid"

The report was prepared by Quanta Technology, LLC. Because of the subject matter and the nature of the analysis, the report is very technical. This short paper is intended to help readers understand some of the major points in the report.

The power industry's reliability standards do not adequately address many of the challenges facing the industry. For instance, reliability standards fail to consider the risks of accelerated (or premature) retirement of coal-fired generating capacity and the possibility that natural gas might not be available when needed to generate electricity.

The Quanta study illustrates the potential consequences of ignoring these two risks — coal retirements and fuel insecurity — for the PJM grid. (PJM relies on coal and natural gas for roughly 70% of its electric generating capacity.) To assess these consequences, Quanta modeled nine scenarios to determine whether any of them would result in a violation of industry standards for transmission security and resource adequacy, which are measures of grid reliability.[i]

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The scenarios are based on assumptions regarding the retirement of coal-fired electricity generation (zero, 15 GW and 30 GW of premature coal retirements) and the unavailability of natural gas-fired generation (zero, 21 GW and 56 GW) due to disruption or curtailment of fuel.[ii] (The report provides further explanation for these assumptions.) Of the nine scenarios modeled by Quanta, two were reference cases (winter and summer); four assumed premature coal retirements; two assumed premature coal retirements along with gas interruptions; and one assumed only gas interruptions (no premature coal retirements).

Quanta's modeling confirmed that the PJM grid is reliable under the current capacity oversupply condition in PJM. However, when more coal-fired generation retired prematurely and natural gas-fired generation experienced supply disruptions, the PJM grid could not meet reliability criteria for transmission security, resource adequacy, or both under seven of the nine

scenarios. Among other things, the Quanta study shows that PJM will lose its resilience to gas outages if coal retirements continue.

Transmission Security Transmission security refers to the ability of the electricity grid to withstand disturbances such as short circuits or unanticipated loss of system components.[iii] NERC's reliability standard was used as the basis for assessing transmission security for each of the nine scenarios. Quanta's modeling shows that accelerated coal retirements and gas outages lead to a significant number of transmission security violations across the scenarios ranging from nine violations to as many as 76 violations. Eleven utility service areas out of the 20 that comprise the PJM footprint would experience load shedding or rotating blackouts in order to maintain grid reliability under three of the scenarios.

Resource Adequacy Resource adequacy refers to the ability of the power system to supply electricity to consumers at all times.[iv] Accelerated coal retirements and gas outages could lead to reliability violations, measured as loss-of-load expectation (LOLE). NERC standards require that LOLE cannot exceed one day of lost load in ten years, which equates to an LOLE of 0.1 day/year. For the nine scenarios analyzed in the study, two met the NERC standard but seven showed violations. The LOLE for these seven scenarios ranged from 0.114 day/year to 0.575 day/year, which means the grid would not be considered reliable under these seven scenarios.

Fuel Security Fuel security generally means having adequate fuel on site.[v] However, there is no resilience standard for the power industry right now, and the organized electricity markets do not price resilience attributes, especially fuel security. The Quanta study illustrates the adverse consequences of fuel insecurity and more coal retirements. Steps — in particular, valuing fuel security — should be taken quickly to avoid the prospect of a less reliable and less resilient grid.

Other Attributes Other attributes provided by retiring coal-fired power plants are necessary for grid reliability and resilience. These include voltage support, frequency management and stabilizing inertia. Further study is necessary to assess the potential effects of premature retirements on these other reliability attributes.

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[i] Adequacy and security are two key aspects of reliability that broadly ensure the continued operation of the system over a broad spectrum of conditions and following a wide range of probable

contingencies. Adequacy addresses whether in aggregate there is enough generation to meet electricity demand. Security addresses whether enough generation exists at key locations throughout the grid to support stable operation of the grid.

[ii] The probability and amount of gas interruptions are influenced by factors such as the commercial gas supply arrangement (firm or non-firm), the supplier's core business (LDC or interstate pipeline), the backup fuel (single or dual fuel), and the location within PJM (East Coast or Midwest).

[iii] More precisely, transmission security refers to planning and operating the system in a way that anticipates the possibility of failure of key system elements in order to minimize the loss of service to large groups of customers, to not cause any area of the interconnected system to become unstable and lose its integrity, and to not cause generation or transmission equipment to operate outside their normal limits.

[iv] Resource adequacy refers to the amount of capacity needed to serve a forecasted peak load while meeting the required loss of load expectation (LOLE) criterion. The LOLE criterion defines the adequacy of capacity that ensures that load cannot exceed available capacity, on average, more than one day in 10 years.

[v] Fuel security refers to the capability of the resource (e.g., a coal-fired power plant) to store fuel on site in order to limit exposure to a single common event and maintain its ability to deliver maximum energy output, independent of any external fuel delivery infrastructure.