Exelon Feedback on Valuing Fuel Security Scope

PJM's market rules are not designed to consider, let alone ensure, the fuel security needed to serve the 65 million people in the PJM region or to value fuel secure, resilient resources. PJM has properly identified fuel security as an unaddressed resilience risk that must be further analyzed and addressed through reforms that adequately value the resilience contributions of fuel-secure resources and ensure fuel-security is preserved. Exelon supports PJM fully in this effort.

But PJM's approach is too narrow. Specifically, PJM underestimates the range of threats and the potential duration of critical infrastructure outages (particularly gas transmission facility outages) that the PJM region faces. As a result, any PJM fuel security study based on these underestimated input assumptions will be severely inadequate. Thus, as elaborated (on pages 5 - 9) below, Exelon recommends several enhancements to PJM's study so it reflects all credible and reasonably foreseeable fuel security challenges over foreseeable durations. For example, Exelon recommends that PJM consider long-term pipeline outages and/or underground storage restrictions affecting multiple facilities and pipeline components. Exelon also proposes a baseline scenario from which PJM should calibrate needed market reforms. Further, Exelon suggests modification to the timing of the proposed "phased approach" that PJM plans to undertake, so that critical national security inputs from government agencies regarding threat priorities can be incorporated in a timely manner into PJM's fuel security study. Finally, solving PJM's fuel security challenges may lead to significant environmental impacts if the emissions implications of potential future fleet compositions are not taken into account. Thus, PJM should calculate and make available the environmental costs and impacts of its current resource portfolio during stressed conditions as well as that of the expected portfolio of resources as a result of any potential fuel security solutions. Exelon has attached a report by Dr. Paul Stockton, former Assistant

Secretary of Defense for Homeland Defense and America's Security Affairs, further describing many of these recommendations.

Fuel Security Poses a Significant Resilience Risk

PJM is correct to undertake an analysis of fuel security at this time. PJM's aggregate supply portfolio is quickly transitioning toward an over-reliance upon gas-fired resources that will challenge system resilience and could result in significant hours of unserved energy if multiple natural gas pipelines are interrupted for an extended period of time.[1] In 2005, coal and nuclear resources generated 91% of the electricity on the PJM system. Over time, state and federal policy initiatives aimed at reducing environmental emissions, a wholesale market design that ignores fuel security, technology improvements, and overall economics spurred a shift from coal to natural gas and renewable generation. From 2010 to 2016 in PJM, coal-fired units made up 79% of the megawatts retired, and natural gas and renewables made up 87% of new megawatts placed in service.[2] Recent retirement announcements (including TMI, Beaver Valley, Davis-Besse and Perry) reflect that in excess of 5,000 MW of nuclear resources plan to retire in PJM in the near future. Reflecting further potential financial struggles by nuclear resources, in the 2018 PJM Base Residual Auction, 10.6 GW of nuclear capacity representing 30% of the nuclear capacity in the PJM region did not clear, a 200% increase from the previous year. At the same time, nuclear resources have been the most resilient, fuel-secure resources in PJM, reflecting stellar performance during the 2014 Polar Vortex, the 2017/18 cold snap and other extreme events.

The nuclear resources facing premature retirement will be replaced with natural gas resources and its "just-in-time" fuel delivery system with very finite back up capability. This trend poses significant common mode failure risks that PJM does not consider as part of its current resource adequacy

[1] ICF, *The Impact of Fuel Supply Security on Grid Resilience in PJM- Final Report*, *Page 2* (June 8, 2018)
[2] PJM Interconnection, *PJM's Evolving Resource Mix and System Reliability*, Page 9 (March 30, 2017)

construct. Numerous reliability and resilience experts have recently expressed concern with this trend. For example, NERC points out in its recent Summer Assessment report that "the growing reliance on natural gas continues to raise BPS reliability concerns."[3] PJM has found that a single gas pipeline in the PJM region serves more than 11,000 MW of generation,[4] and a recent study by ICF examining generation clusters in PJM and New York found that 18,000 MW[5] of generation in PJM alone would be at risk from an extended pipeline outage[6]—all in the most densely populated parts of the Eastern United States.

Throughout the history of the industry, system operators have avoided an over-reliance on one resource type for good reason - system resilience requires fuel security that is fostered by fuel diversity. For example, in a report on the coal strike of 1977-78, both the diversity of generation fuel types and diversity of fuel supply sources were cited as major factors in permitting the industry to minimize the adverse impact of the strike.[7] When system operators have failed to account for fuel security, impacts have been dramatic for consumers. For example, during a 1994 cold spell, non-firm gas supply was interrupted resulting in PJM and Virginia Power curtailing firm electric customers to maintain system reliability, and that was at a time that the system was much less reliant on natural gas than it is today.[8]

As described above, absent swift action to value fuel security, the trend of fuel secure resource retirements will continue, and they will be replaced predominantly with natural gas resources reliant

[3] NERC's 2018 Summer Reliability Assessment, Page 6. *See also* National Academics of Sciences, Engineering, and Medicine, *Enhancing the Resilience of the Nation's Electricity System,* page 82 (2017) (finding that "constraints in natural gas infrastructure have resulted in shedding of electric load, and growing interdependency of the two systems poses a vulnerability that could lead to a large-area, long duration blackout.")
[4] PJM Transmission Expansion Advisory Committee, Reliability Analysis Update (Sept. 14, 2017), http://pjm.com/-/media/committees-groups/committees/teac/20170914/20170914-reliability-analysis-updates.ashx.
[5] Part of a total of 27,000 MW in the whole Mid-Atlantic region.
[6] ICF, *The Impact of Fuel Supply Security on Grid Resilience—Final Report*, Page 1 (June 8, 2018)
[7] NERC, *The Coal Strike of 1977-78: Its Impact on Electric Bulk Power Supply in North America* (May 30, 1978)
[8] Report by the Blue Ribbon Task Force to the NERC Board of Trustees, *Report on Electric Utilities' Response to the Cold Wave of January 1994* (April 11, 1994)

upon gas pipeline delivery and storage as well as finite back up fuel sources. PJM's analysis should carefully consider the limits of such a portfolio during high-impact, low-frequency events caused by both weather and man-made contingencies and determine the needed fuel security constraints to appropriately mitigate the tremendous risks inherent during such scenarios. The grid is changing faster than anyone anticipated, and the consequences of inaction are permanent, particularly when it comes to nuclear resource retirements. Further, the grid and its vulnerabilities are well understood by our adversaries.

PJM's Proposed Phase I Analysis Is Too Narrow

Performing a robust fuel security analysis, as proposed by PJM in Phase I, is the first and most critical step in the entire PJM initiative. PJM should commence the Phase I analytics immediately in order to define a reasonable baseline scenario that can be used as the basis for taking action to ensure resilience starting with the 2019 Base Residual Auction. This baseline scenario can be modified later to the extent that more information becomes known, but PJM should not delay in moving to develop its initial version.

However, PJM's approach as drafted in its April 30, 2018 scoping document is too narrow and will not sufficiently inform the incremental resilience needs of PJM customers. PJM proposes to extend the recent experiences of the Polar Vortex and the recent Cold Snap to simulate the occurrence of high-impact, low-frequency events, employing a 12-14 day event duration assumption. PJM will stress-test the system under various fuel supply disruption scenarios to understand reliability outcomes resulting from the current capability of local onsite fuel and back-up fuel. However, constraining the study assumptions to the severity and duration of recent historical weather events is the equivalent of what the government and the airline industry did on September 10, 2001 and fails to reflect all realistic potential scenarios that PJM could face. As Dr. Stockton suggests, PJM needs to modify its disruption

scenarios and stress testing in both scope and duration taking into account not just weather events that have already transpired, but realistic scenarios caused by manmade interruptions. As elaborated below, Dr. Stockton generally concludes that since adversaries would attack more than one pipeline, PJM should expand the scope of its study to consider multiple simultaneous pipeline outages and/or restrictions on storage and assume that repair of such infrastructure could take many months. For example, the 2016 Spectra Pipeline explosion in Western Pennsylvania took six months to repair under ideal non-winter, blue sky conditions. According to Spectra, this event was caused by corrosion near a weld that progressed faster than usual causing the pipeline to fail, and could have been far worse if caused by a calculated attack coupled with a cyber-attack during an extreme weather event.[9] A poorly defined study will lead to a poorly defined solution and continued vulnerabilities and exposure to risk that threaten the health and safety of the consumers throughout PJM, as well as national security.

Exelon's Proposed Modifications To The Phase I Analysis

Dr. Stockton's recommendations are set out in the attached memo, *Valuing Fuel Security: Recommendations on Study Scope and Simulated Disruptions*. Dr. Stockton recommends the scope of the analysis be expanded to include multiple pipelines and/or storage facilities and recommends extension of the duration of the disruption scenarios to comport with man-made threats.

To this end, Exelon suggests that PJM should consider the following principles when developing the Phase I analysis.

- Evaluate a full 90-day winter. While the specific events (extreme weather and man-made infrastructure disruptions) that PJM analyzes may not last the whole winter, extremely stressful events can cause later resilience issues even after the event itself

[9] Debra Erdley, *6 Months After Salem Township Explosion, Spectra Energy Has Gas Pipelines Running*, TribLive.com (Nov. 18, 2016), http://triblive.com/local/westmoreland/11496039-74/pipeline-spectra-explosion.

has passed. For example, if the collective oil inventory is depleted in a weather event, the system may have difficulty meeting load later in the season even with more normal conditions due to lack of oil resource availability. A Navigant study confirms that, in the PJM region, more than 50% of dual-fuel and oil-only resources would be offline due to a lack of fuel after four days of full-load operation, and nearly 80% would be offline after seven days.[10] Efforts to refill oil tanks during a cold winter present numerous additional challenges. Thus, PJM's analysis should cover the full winter, even if the individual disruptions are shorter than the entire winter.

- Develop a "stress weather" scenario that combines a multi-week extreme cold snap with an overall colder-than-average winter. Resilience issues can arise from a multi-week extremely cold period like that experienced this past winter, but can also arise from the cumulative effect of an overall cold winter, with multiple cold periods. In performing the full winter analysis we suggest above, PJM should develop a full-winter "stress weather" scenario that includes a 14-day extreme period with temperatures and wind-chill comparable to the 2013/14 Polar Vortex, but also includes overall average temperatures over the course of the entire winter consistent with the coldest historic winter.
- Examine infrastructure disruption scenarios lasting at least 90 days. PJM's proposal to limit the duration of the analysis to at most 14 days is not adequate to describe the potential duration of infrastructure disruptions. Major pipeline disruptions can, and have in the past (such as the recent Spectra disruption discussed above), lasted up to six months. Thus, a full-winter, 90-day disruption is quite plausible and an appropriate stress case to consider. A full winter-long disruption is also consistent with the duration

[10] Navigant Consulting, Inc., *PJM Liquid Fuel Survey and Research Results and Recommendations* (Apr. 25, 2018) ("PJM Liquid Fuel Survey") attached to Exelon's May 9, 2018 Response in FERC Docket No. AD18-7.

ISO-New England utilized in developing its recent Operational Fuel Security analysis. While it may be appropriate to also consider shorter-duration infrastructure disruption events (such as 15, 30, and 60 days), a full winter-long disruption should serve as the baseline scenario used to develop a market-base resilience solution.

- Consider broader gas system disruptions when developing infrastructure stress events. As Dr. Stockton elaborates in his attached report, gas system disruptions that should be studied include multiple pipeline outages as well as disruptions of other gas system components such as storage facilities, network connected components and other facilities. While a range of potential infrastructure disruption scenarios are possible, in developing the baseline stress scenario, PJM should consider the most disruptive gas contingency in terms of gas generation affected. A recent study conducted by ICF showed that an extended pipeline outage would put 18,000 MW of generation in PJM at risk.[11] In follow up work by ICF that included a plausible amount of premature nuclear generation retirements in PJM and loss of multiple gas pipelines for a long duration, ICF found there would be as much as 280 hours of unserved energy which would impact customers, businesses and commu**n**ities.[12]
- Consider the effect of priority heating demand on any gas contingency. LDC heating demand typically has priority over power generation demand. Because of this, a full disruption of a given pipeline is not necessary to fully cut off the supply of gas for downstream power generators. Accordingly, in modeling its infrastructure development scenarios, PJM should assume that gas generators downstream of the gas contingency have no access to gas for the duration of the disruption, due to being pushed out by higher priority heating load. EIA data over the past two winters (Dec-Jan) confirms this

[11] ICF, *The Impact of Fuel Supply Security on Grid Resilience in PJM-Final Report*, Page 2 (June 8, 2018)
[12] ICF, *The Impact of Fuel Supply Security on Grid Resilience in PJM-Final Report*, Page 2 (June 8, 2018)

point; it shows that with between 25% and 40% of gas generation resources unavailable, there may be ”no gas for electric generation” due to other requirements like home heating load. [13] Similarly, a 2014 Eastern Interconnection Planning Collaborative report showed that about 38.7 GW of the gas-capable generation in PJM is located behind LDC citygates, the points at which interstate or intrastate pipelines transfer gas to the local delivery system.[14]

- Evaluate simultaneous weather and man-made infrastructure/cyber events. The highest stress resilience scenarios arise when extreme weather co-occurs with an infrastructure disruption. Therefore, any baseline scenario should jointly consider the extreme weather scenario as occurring simultaneous with a high-impact, 90-day infrastructure disruption scenario.
- Evaluate all scenarios against a range of future generation portfolios. Exelon agrees with PJM’s proposed generation portfolio scenarios (“base,” “stressed” and “high stressed”). Any weather and infrastructure disruption scenario should be evaluated under each generation portfolio.
- Consider scenarios that assume no “help” from other regions as those other regions may be struggling themselves to serve their load and have no excess to spare.
- Consider a summer stress scenario. Considerable attention has been devoted to winter periods, but given changes in summer load and other factors, it would be prudent for PJM to also consider a high-stress summer scenario.

Given these principles, Exelon proposes the following scenario as a reasonable baseline for developing a resilience solution.

[13] EIA, Natural Gas Consumption by End Use Data, Release Date 05/31/2018
[14] Eastern Interconnection Planning Collaborative, *Gas-Electric System Interface Study Existing Natural Gas-Electric System Interfaces*, Page 19 (April 4, 2014).

- A "stress weather" winter, combining a 14-day period of extreme cold and wind chill (consistent with those experienced during the 2013/14 Polar Vortex) with full-winter average temperatures consistent with the most extreme winter over history.
- A significant 90-day disruption of the pipeline system entering Eastern PJM that is sufficient to cause all gas generation within MAAC to have no access to gas for the entire winter, given the priority of heating load coupled with extreme winter temperatures.
- Generator forced outages consistent with those observed under recent winter stress conditions.
- Modeling of backup liquid fuel capability that considers expected fleet storage levels and limited re-supply capability especially as would occur during winter stress conditions and/or during a long-term outage where secondary supply impacts (e.g., refinery outages as a result of insufficient electric service) could exacerbate re-supply problems.
- Evaluate this scenario using PJM's proposed "base," "stressed," and "high-stressed" generation portfolios. The high stressed generation portfolio should not assume that only nuclear resources that did not clear will retire, rather it should assume that all financially stressed nuclear resources will retire.[15]

This scenario combines plausible extreme weather and man-made infrastructure disruption scenarios consistent with observed historical events. This scenario is consistent with the guidance provided by Dr. Stockton in his attached memo and aligns with the first manmade disruption scenario he recommends

[15] While failing to clear a capacity auction is a clear indication of likely financial stress, some nuclear resources that clear may also be under financial stress and thus candidates for retirement. *See* ICF*, The Impact of Fuel Supply Security on Grid Resilience in PJM – Final Report* (June 8, 2018)

that proposes PJM examines a reduction of a realistic percentage of delivery capability on particularly constrained portions of pipelines and/or storage facilities in the PJM region.[16]

While this scenario should serve as the baseline for any solution, PJM should consider a range of other scenarios varying along the various identified dimensions (such as weather; number, impact, and duration of infrastructure/cyber disruptions; availability of liquid fuel resupply) to further inform the stakeholder discussion. Consistent with Dr. Stockton's recommendation, PJM should also evaluate a realistic but extreme contingency scenario that disrupts 80% of the natural gas pipeline infrastructure across the entire PJM region for six months. This scenario represents the severe threat that a major state adversary might pose. This scenario should be conducted using the same assumptions as described above for the baseline scenario.

Exelon Recommends that PJM Coordinate with Federal Agencies on Resilience Threats Now

PJM's "Phase III: Ongoing Coordination" is a critical part of the overall success of this effort. While PJM should immediately begin modeling Phase I as suggested by Exelon, PJM must have additional input from DOD, DHS, FERC, and DOE to assess the level of fuel security necessary to protect our Nation or its studies will miss critical threats. PJM must consult with and incorporate the recommendations of the DOE and other national security organizations in its modeling scenarios now. Dr. Stockton also highlights the need for PJM to reach out to FERC, DOE, and other Federal partners for a near-term review of the disruption scenarios he recommends.[17] Over the long term, PJM's effort should be informed by a design-basis threat (DBT) from the federal government to identify resilience threats and provide a baseline against which PJM can measure its efforts at creating a resilient grid. While a specific DBT may not be available in the first phase due to timing, PJM should consult with the

[16] Paul Stockton, *Valuing Fuel Security: Recommendations on Study Scope and Simulated Disruptions*, Page 2 (May 29, 2018).
[17] Paul Stockton, *Valuing Fuel Security: Recommendations on Study Scope and Simulated Disruptions*, Page 6 (May 29, 2018)

organizations to obtain initial feedback on national security threats to consider in the first year it conducts its analysis, and thereafter, PJM should build a model sufficiently robust to include a DBT once established and share with the DOE, on a classified basis, the threats that can debilitate the PJM system.

PJM Should Provide Transparency on Environmental Impacts

For each of the scenarios that PJM models, it should provide transparency into the environmental and emissions costs that will result. Stakeholders should be provided a comparative analysis that shows the current emissions profile in PJM and changes to that profile under the various scenarios that are being analyzed in PJM's Valuing Fuel Security effort.

New England's fuel security challenges are well known. As a result of retirements of fuel secure resources and increased reliance on dual fuel natural gas-fired generators, that region must turn to burning oil when the system is stressed. This past winter, two million barrels of oil were burned in less than two weeks—more than double the amount burned in the region the entire year before. The carbon and other air pollution impacts of those circumstances are troubling for two reasons. First, they challenge the ability of those regions to meet their emissions goals now and in the future. Second, they stand to exacerbate the severe weather events that are interrupting electric service to customers in the first place.

In PJM, this risk is even more significant. If PJM plans to meet its fuel security challenges by retaining resources that burn coal or by incentivizing the addition of oil storage, it will be contributing to the very problem it is trying to solve. Planning a generation system that is resilient must include planning for a system that is both able to withstand interruptions and also does not contribute to interruptions by exacerbating climate change. To prevent future instances like this, PJM must include within its analysis an evaluation of the emissions implications of greater reliance on coal and dual fuel resources during periods of natural gas disruption.

Feedback on Next Steps

Exelon is encouraged by PJM's willingness to work with stakeholders on this important resilience issue. We support PJM's effort to prioritize this issue of critical importance and push for a resolution in advance of the May 2019 Base Residual Auction. To that end, Exelon recommends that PJM incorporate Exelon's suggested improvements into its proposal. In addition, PJM should provide updates at future MRC meetings, and request that PJM also provide regular milestone reports on the progress of each phase. Such reports will enable stakeholders to provide additional feedback on the analysis contemporaneous with the undertaking, instead of only at the end when it is too late for PJM to act on any suggestions. Exelon also requests that PJM provide stakeholders with additional detail on the specifics behind the disruptions to fuel delivery systems that will be analyzed, and the composition of the three portfolios that PJM will be analyzing. We look forward to engaging with PJM on these efforts.