Introduction

Resilience describes a broad array of low-probability but high-impact risks at all stages of the production, transmission and distribution of electricity. PJM Interconnection is uniquely positioned to see the bigger picture of the many factors that affect the resilience of the grid. PJM now seeks to isolate one type of resilience risk: fuel security. Fuel security focuses on the vulnerability of fuel supply and delivery to generators and the risks inherent in increased dependence on a single fuel-delivery system.

In March 2017, PJM published an analysis of the reliability attributes associated with various potential future resource mixes.[1] PJM's analysis concluded that its bulk electric system could be operated reliably under an array of future supply portfolios. However, the scope of the analysis did not include the resilience of the system with various potential portfolios nor the risks associated with significant disruptive events.

As the paper noted: "Heavy reliance on one resource type, such as a resource portfolio composed of 86 percent natural gas-fired resources, however, raises questions about electric system resilience, which are beyond the reliability questions this paper sought to address."

As is the case with reliability standards, PJM believes the most effective way to address fuel security is to define and establish fuel security criteria and then use market forces to allow all resources to compete to meet those criteria. The PJM markets can provide excellent, fuel-neutral tools to value identified and verified fuel security attributes. Additionally, the PJM markets offer a competitive environment to deliver fuel-secure electricity in the most efficient and cost-effective manner to customers. The market can also send a price signal that works to incent investment in fuel-secure infrastructure.

This market signal can be used as one data point to assist in valuing various alternatives such as the benefits of new pipelines, the benefits of resources with on-site fuel and the value of new technologies that promote an array of fuel-secure resources. Market participants would respond to the signal with the most cost-efficient approach to ensure fuel security. **The market-based approach outlined below can work to achieve a cost-effective, fuel-secure fleet of resources.**

As defined by PJM, fuel security is the ability of the system's supply portfolio, given its fuel supply dependencies, to continue serving electricity demand through credible disturbance events, such as coordinated physical or cyber-attacks or extreme weather that could lead to disruptions in fuel delivery systems, which would impact the availability of generation over extended periods of time. To define potential fuel-security criteria, PJM needs to understand the fuel-supply risks in an environment trending towards greater reliance on natural gas supply and delivery.

The goal is to identify triggering thresholds (such as a simulated loss of load) that indicate locations on the system where additional fuel security assurance is needed. PJM could then model those locations as constraints in the capacity market, just as PJM models transmission constraints today when determining the parameters that form the locational requirements in the capacity auction. As with transmission constraints, modeling fuel security would only

[1] http://pjm.com/-/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx?la=en

result in price separation if the results demonstrate a constraint. Ideally, if analysis indicates the need for constraints, PJM would implement them by the May 2019 Base Residual Auction.

As a first step, PJM will perform targeted analyses to identify fuel security risks that could affect specific locations on the system (or depending on the nature of the fuel supply risk on the aggregate PJM system) and establish criteria to apply to existing market mechanisms in order to produce efficient and cost-effective results for customers. This document outlines the objectives for this study, defines the approach fundamentals, including assumptions, and establishes the timeline for completion.

Proposed Approach

PJM recognizes that assessing fuel security is complex and best tackled in phases. The first phase is to assess, via analysis, the scope of fuel security vulnerabilities and the development of criteria. The following phases would use the results of the first phase as input to determine the valuation of fuel security attributes. PJM anticipates overlap between phases as it continues to refine the analysis, criteria and methods for valuing fuel security.

Phase I: Analysis – Identify potential system vulnerabilities on a locational basis and develop fuel security criteria to address those vulnerabilities.

Phase I is intended to identify potential system vulnerabilities and to determine attributes such as requirements for amounts of on-site fuel and dual-fuel capability, among others, to ensure that peak demands can be met during realistic but extreme contingency scenarios in various supply portfolios.

As PJM concluded in its March 2017 report, PJM's current fuel portfolio is reliable, diverse and among the highest performing of those studied. It is well supplied with the required generator reliability attributes. The PJM system can remain reliable with the addition of more natural gas and renewable resources. However, an increased reliance on any one resource type introduces potential fuel security risks not recognized under existing reliability standards.

Such risks could include the deliverability logistics of fuel supplies during stressed conditions over time as opposed to more momentary interruptions that otherwise are considered through the procurement of reserves. The intent of Phase I will be to stress-test the system under various extended fuel supply disruption scenarios in order to better understand reliability outcomes resulting from the current capability of local onsite fuel and back-up fuel.

This is different from the objective of the Capacity Performance enhancements already implemented in the PJM capacity market. Capacity Performance ensures that individual resources are prepared to perform when the system needs them the most. The vulnerabilities that the Phase I analysis will identify and model as constraints may be beyond the ability of any individual unit owner to control through more secure fuel contracts or investment in particular units.

Phase II: Modeling – Work through the PJM stakeholder process to incorporate vulnerabilities, on a locational basis, as constraints in PJM's capacity market (similar to PJM's modeling of transmission constraints today).

This would allow for the proper valuation of needed locational attributes as well as competition among resources that today or in the future can provide those attributes to ensure a resilient grid. The results of the Phase I analysis will be used in Phase II to help model constraints as part of the planning parameters in PJM's capacity market to help identify and value needed fuel security attributes at particular locations on the system.

Recognizing that the PJM region is large and diverse, generation located, for example, on top of a Marcellus shale field does not face the same fuel security issues as a generator more distant from supply and connected to a lateral pipeline served by a single natural gas distribution company. Similarly, delivery mechanisms for coal and oil differ across the region. For these reasons, PJM recommends starting with a locational analysis focused on specific fuel delivery vulnerabilities, which will differ depending on geography. These constraints would then be modeled in the capacity market along with existing and projected transmission constraints to ensure that each zone and sub-zone in PJM is able to maintain reliable service during a disruptive event that could last several days. As with transmission constraints, modeling fuel security would only result in price separation if the results demonstrate a constraint.

Phase III: Ongoing Coordination – Address any specific security concerns identified by federal and state agencies such as physical and cybersecurity hardening of critical assets that are cleared in the market.

In Phase III, PJM would work with the U.S. Department of Homeland Security, the U.S. Department of Energy, the Federal Energy Regulatory Commission, states, stakeholders and others to ensure that the results are consistent with identified security needs in the PJM footprint, including service to key military installations and other identified security concerns. Further, those facilities that clear as fuel-secure resources in the capacity market would need to assure regulators that they are "hardened" to address identified physical and cybersecurity threats and that the fuel system upon which those resources depend are similarly able to withstand identified physical and cybersecurity threats.

Assumptions

The following are a few high-level indicative assumptions that could be utilized for the analysis in Phase I:

- Generator forced, planned and maintenance outage rates (other than outages related to fuel supply) will be consistent with recent winters
- Oil-fired and dual-fuel generator withdrawals of oil and ease of replenishment will be modeled on a locational basis, taking into account the locational supply chain and contractual arrangements associated with such replenishments. PJM will study several different capacity supply portfolios under multiple different gas-availability scenarios.

- The study will be simulated under 2017-18 Cold Snap extended cold weather conditions and under 2014 Polar Vortex loads and wind chill levels.[2]
- The study will be conducted for the RTO region and sub-regions.

Analysis Scenarios

PJM will create several capacity portfolio scenarios for the purposes of the study. They include:

- **Base Portfolio**: This scenario includes the 2020-21 PJM resource portfolio with scheduled retirements in addition to other retirements in order to have the Installed Reserve Margin (IRM) equal the approved value of the 2017 PJM Reserve Requirement Study of 16.6 percent.[3]
- **Stressed Portfolio**: This scenario includes the base portfolio scenario along with additional coal and nuclear retirements.
- **High-Stressed Portfolio**: This scenario includes the base scenario along with an assumption that an increased percent of coal and nuclear are retired and replaced with natural gas within the same zone as the retired resources.

Disruptions

PJM will simulate disruptions to fuel delivery systems that could be the result of credible extreme events such as coordinated physical or cyber-attacks, extreme weather, etc. The following is a description of the disruption scenarios:

- No disruptions; generators have access to supply throughout the winter, subject to current pipeline capacity.
- Reduction of a realistic percentage of delivery capability on particular constrained portions of pipelines in the PJM region. This would address the potential for a significant disruptive event to degrade the pipelines' ability to deliver to a set of generating units.
- In addition to reduced supply availability over longer periods, study a few realistic but extreme contingencies such as a *force majeure* event on key delivery facilities.
- In addition to reduced gas availability, analyze other fuel supply disruptions.

Each of these disruptions will be applied to the three capacity portfolio scenarios described above.

[2] http://www.pjm.com/-/media/library/reports-notices/weather-related/20180226-january-2018-cold-weather-event-report.ashx
[3] http://www.pjm.com/-/media/committees-groups/committees/pc/20171012/20171012-item-03a-2017-pjm-reserve-requirement-study.ashx

Anticipated Outcome

PJM anticipates completing the study within the next several months. The results will be discussed with PJM stakeholders and state and federal agencies.

PJM intends to use the study results to define (if analysis indicates they are necessary) specific fuel-security criteria that could be implemented as constraints in the capacity market for application in the next possible Base Residual Auction. These constraints will be defined in a fuel-neutral manner, such that all resources are able to compete to meet them. Including such criteria in the capacity market modeling would ensure that the capacity market commits resources based on the least-cost set that ensures resource adequacy including fuel security considerations.

Approach Rationale

PJM believes the most effective way to address fuel security is to define and establish fuel security criteria and then use market forces to allow all resources to compete to meet those criteria. The competitive markets remain the best mechanism to use to meet the needs of maintaining a reliable and fuel-secure system at the lowest reasonable cost to consumers. Establishing the criteria and constraints proactively will allow them to be modeled in the capacity market before the PJM system is at a point where the constraints could be violated. By doing so, the market construct will be prepared and configured to recognize these constraints if and when they do arise, so that the market can commit resources on the basis of those constraints. Moreover, using the existing market constructs is expected to limit significantly the number of instances where out-of-market actions are necessary.

PJM looks forward to working with stakeholders, federal and state agencies on further developing the incorporation of fuel security criteria into its markets going forward.

Proposed Timeline

Acknowledging that valuing fuel security is a complex effort, the proposed approach attempts to organize the effort in incremental phases. The phases are not necessarily contemplated to be sequential and PJM acknowledges that there will be overlap between the phases as we collect feedback and work through the stakeholder process. PJM proposes the following timeline:

- Phase I, initial analysis, completed in 3-4 months
- Phase II completed in 4-5 months
- Phase III ongoing

These phases and timeframes will be fluid and dynamic. Ideally, if analysis indicates that fuel security constraints are necessary, they would be implemented by the May 2019 Base Residual Auction.

Stakeholder Feedback

PJM welcomes stakeholder feedback regarding the scope of this analysis. To that end, PJM will schedule a special MRC conference call in the near future to garner stakeholder feedback on this plan. Of course, protections, including those addressed through PJM Critical Electric Infrastructure Information rules, would be needed to shield the exact input and results of that modeling to prevent vulnerabilities from being publicly released. PJM is prepared to work with the Federal Energy Regulatory Commission and stakeholders to develop appropriate mechanisms to achieve appropriate transparency.