Fuel Security

Analyzing Fuel Supply Resilience in the PJM Region

Summary of Results, Conclusions and Next Steps

Highlights

- PJM's fuel security analysis is the next step in ensuring the resilience of the grid, focusing on one of its most important elements – fuel supply.
- The PJM system is reliable today and will remain reliable into the future.
- In the analysis, PJM stress-tested the fuel delivery systems serving generation in the PJM region under extreme scenarios to identify when the system begins to be impacted and to identify key drivers of reliability risk.
- In order to enhance the fuel security of the grid into the future, PJM believes market-based mechanisms for retaining or procuring resources with the necessary attributes should be explored.

Analysis and Results:

- PJM looked five years into the future, using a 2023/2024 system model, to analyze more than 300 different scenarios ranging from typical operations to extreme scenarios, considering elements like generation retirements, customer demand, fuel delivery and fuel disruptions.[1]
- In a 14-day period of cold weather with typical winter load and generation retirements announced as of Oct. 1, 2018, PJM's system can withstand an extended period of stress while remaining reliable. Even in an extreme scenario, such as an extended period of severe weather combined with high customer demand and a fuel supply disruption, the PJM system would still remain reliable.
- As in any stress test, the analysis was intended to discover the tipping point when the PJM system begins to be impacted. Looking five years into the future, under escalated retirement scenarios combined with extreme winter load, the system may be at risk for emergency procedures and load loss.
- Key elements such as on-site fuel inventory, oil deliverability, location of a fuel supply disruption, availability of non-firm natural gas service, pipeline configuration and demand response become increasingly important as the system comes under more stress.
- The development of demand response programs has helped to provide more options for PJM operators and reduced, though not eliminated, the vulnerability of the system to fuel supply disruptions.

Actions:

- While there is no imminent threat, fuel security is an important component of ensuring reliability – especially if multiple risks come to fruition. The findings underscore the importance of PJM exploring proactive measures to value fuel security attributes, and PJM believes this is best done through competitive wholesale markets.
- PJM will continue to engage the Federal Energy Regulatory Commission (FERC) in the national consideration of fuel security issues addressed in FERC's resilience docket.[2]

[1] The analysis is neither meant to be predictive of future conditions nor meant to imply that analyzed scenarios are unavoidable.
[2] https://www.pjm.com/-/media/documents/ferc/filings/2018/20180309-ad18-7-000.ashx

Focus on Fuel Supply

Electricity is a public necessity and is critical to the public health and welfare of the nation. Keeping power available whenever and wherever it is needed is the number one priority of PJM Interconnection and other grid operators. In the last several years, changes in the energy industry and increased cyber and physical threats to the grid and the fuel supply chain serving that grid have introduced a heightened focus on risk. Grid operators around the world find themselves contending with new challenges, including a rapidly changing fuel mix, stressed fuel delivery systems, extreme weather, cyberattacks and physical security threats. As a result, the security of the fuel supply – one component of the resilience of the power grid – has become an increased area of focus.

Fuel Security as a Resilience Effort

Resilience is how grid operators manage the risk of high-impact disruptions, which can happen simultaneously or persist for a period of time. Operators must prepare for, be capable of operating through and be able to recover as quickly as possible from these disruptions, no matter the cause.

There are many dimensions of resilience that span the markets, operations, planning and supporting infrastructures of the grid. In PJM's March 2017 paper, "PJM's Evolving Resource Mix and System Reliability," PJM recognized that the shift in fuel mix and changes in technology raised important fuel security questions. This spurred PJM to undertake an analysis of risks to fuel supply, which is summarized in this document. PJM will publish a detailed report on this analysis, including the background, method, approach, analysis results, conclusions and next steps in December 2018.

Analysis: Assumptions and Scenarios

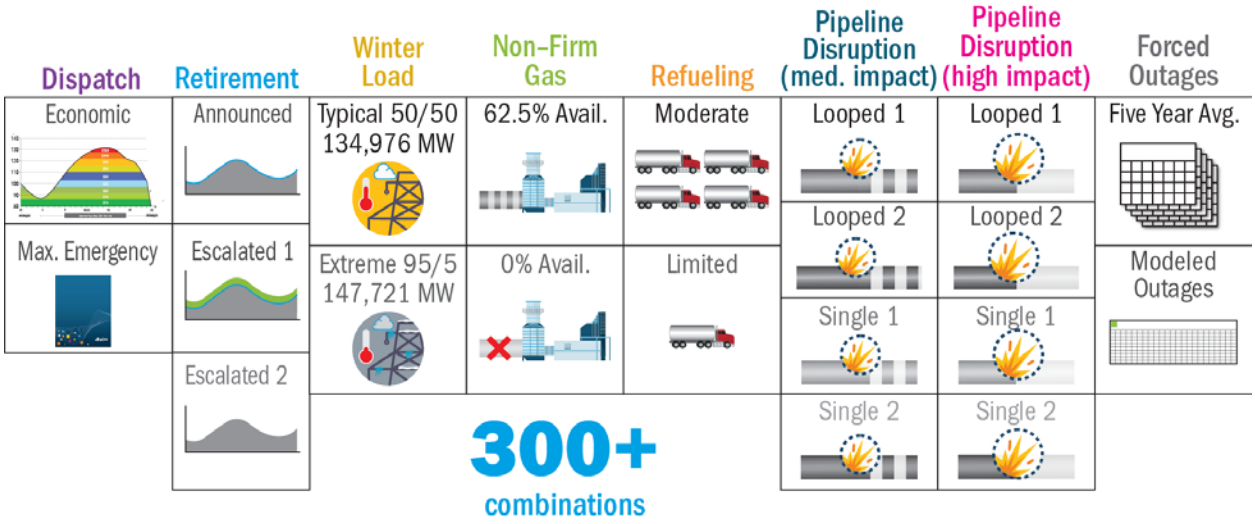
PJM designed its analysis to stress-test the grid under a series of extreme, but plausible events. As in any stress test, the analysis was intended to discover the tipping point at which the PJM system begins to be impacted.

PJM studied more than 300 different scenarios that could occur during an extended period of cold weather, varying elements such as customer demand (also called "load"), fuel availability, oil refueling frequency, generator forced outage rates, retirements and natural gas pipeline disruptions (Figure 1).[3]

In order to develop a robust and plausible set of assumptions, sensitivities and scenarios, PJM analyzed historical weather data spanning more than 45 years, researched previously completed studies, issued supplemental surveys to PJM generation owners, and met extensively with industry groups, generation owners, various companies in the fuel supply chain in the PJM region, government agencies and other system operators.

[3] The impact of available demand response, renewables and energy storage was incorporated in the analysis for all scenarios.

Figure 1: Overview of Assumptions



Why Winter Demand?

PJM selected a 14-day period of cold weather for the analysis. Though PJM consistently sees its highest customer demand during the summer, the greatest strain on fuel supply and delivery occurs in the winter. This is primarily because during the winter, the needs of commercial and residential heating are competing with natural-gas-fired and dual-fuel generators (which generate more than 30 percent of the energy produced in PJM) for natural gas, oil, pipeline transportation and oil deliveries.

Retirements, Load and Disruptions

In the analysis, PJM simulated typical winter load on the system,[4] looking five years into the future and taking into account the announced retirements,[5] new generation slated to be in operation by 2023 and interstate pipeline build-out. This allowed PJM to analyze the assumptions against what it would experience in a typical winter.

PJM then layered in additional assumptions to stress-test the system under more extreme conditions, asking questions such as: "What if the peak load is much higher than usual?", "What if there is a pipeline break at a critical location?", "What if deliveries of fuel don't come in as scheduled?", "What if there are more generator retirements than expected?"

[4] "Typical winter load" is that which would occur about 50 percent of the time and represents a peak demand of approximately 134,976 MW. "Extreme winter load" is that which would occur only about 5 percent of the time and represents a peak load of approximately 147,721 MW.

[5] Retirements announced by Oct. 1, 2018.

The key variables included in the analysis were:

- Availability of non-firm gas service
- Ability of the fuel-oil delivery system to replenish oil supplies during an extended period of extreme cold weather
- Physical breaks at key locations on the pipeline system
- Customer demand (load)
- Generator retirements, replacements and resulting installed reserve margin
- Use of operating procedures to conserve fuel during peak winter conditions

Results: Reliable Under All but the Most Extreme Scenarios

The results of the analysis are summarized in Figure 2 and Figure 3. Each box represents a single scenario, which is color-coded by level of operational procedure. Boxes include all operational procedures up to and including the one indicated by color. For instance, a yellow-colored square would indicate an operational reserve shortage, and some level of demand response would have already been deployed; voltage reduction and load shed would not have occurred.

Labels indicate the following:

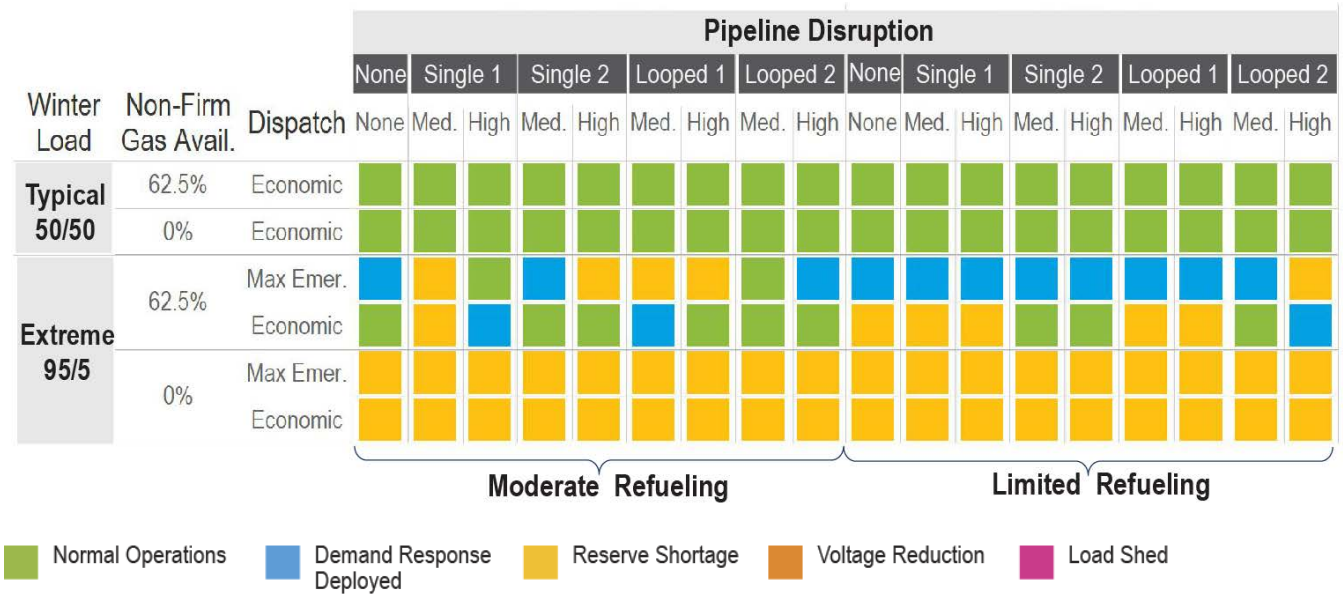
- Winter Load: Typical (134,976 MW peak) or extreme (147,721 MW peak)
- Non-Firm Gas Availability: 62.5 percent or 0 percent available
- Dispatch: PJM's usual economic dispatch or a maximum emergency dispatch
- Moderate/Limited Refueling: Amount of oil refueling
- Single 1/Single 2/Looped 1/Looped 2: Names assigned to simulated pipeline disruptions
- Medium/High: Severity of simulated pipeline disruptions

Announced Retirements, Typical and Extreme Winter Load

The analysis showed no issues on the system in a prolonged period of cold weather with typical winter load,[6] accounting for announced retirements[7] and new generation slated to be in operation by 2023 (Figure 2). Even in a scenario such as extreme winter load[8] combined with a pipeline disruption at a critical location on the pipeline system from which a significant number of generators are served, PJM's system would still be reliable. While there could be reserve shortages in the extreme winter load scenarios, the grid would remain reliable and able to continue to deliver electricity reliably under these extreme conditions.

[6] "Typical winter load" is that which would occur about 50 percent of the time and represents a peak load of 134,976 MW.
[7] Retirements announced by Oct. 1, 2018.
[8] "Extreme winter load" is that which would occur only about 5 percent of the time and represents a peak load of 147,721 MW.

Figure 2: Results: Announced Retirements, Typical and Extreme Winter Load



Escalated Retirements, Typical and Extreme Winter Load

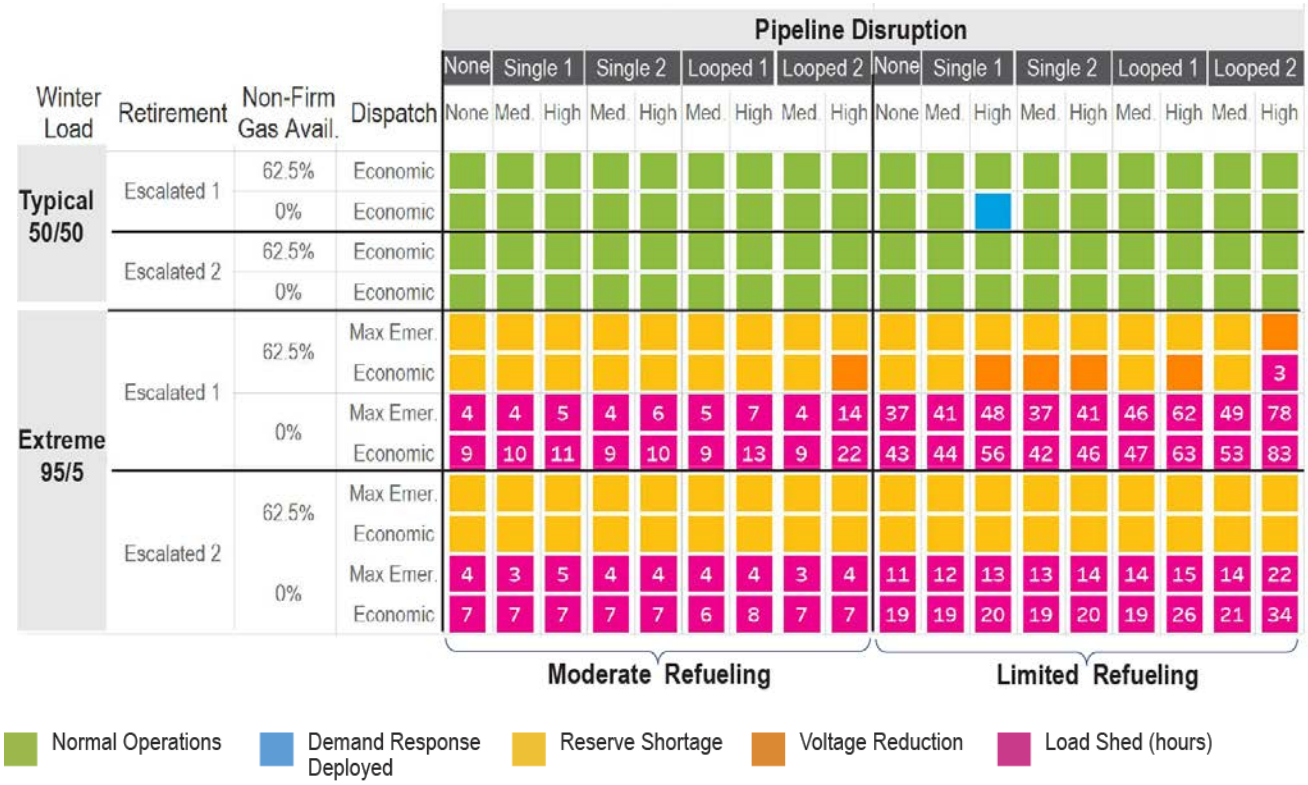
For the more extreme scenarios, PJM analyzed two separate generation retirement scenarios, termed Escalated 1 and Escalated 2. Both Escalated 1 and Escalated 2 included securing enough capacity to meet PJM's installed reserve margin reliability requirement.[9] Escalated 1 modeled generation retirements of 32,216 MW by 2023, with 16,788 MW of capacity added to meet the installed reserve margin requirement. Recognizing that as units retire, market signals could slow the rate of further retirements, Escalated 2 modeled generation retirements of 15,618 MW by 2023 with no capacity replacement.

When combined with extreme winter load, PJM's analysis indicates that the two escalated retirement scenarios have similar results that indicate the system may be at risk for emergency procedures and load loss. A summary of the results of the extreme scenarios with escalated retirements is shown in Figure 3.

PJM acknowledges that its reserves have historically exceeded the installed reserve margin reliability requirement. The escalated retirements are, by design, a stress analysis. The goal is to simulate the retirement of different levels of resources that are financially at risk while maintaining the current installed reserve margin reliability requirement of 15.8 percent. In the Escalated 1 analyses, PJM retired beyond the reliability requirement and replaced up to the reliability requirement. In the Escalated 2 analyses, PJM simply retired up to the reliability requirement and did not replace any of the retirements. The range of retirements analyzed represents possible bounds of retirement levels, recognizing that market signals would limit retirements between those bounds.

[9] In the Escalated 1 scenario, 16,788 MW of replacement resources were added to meet the 15.8% installed reserve margin reliability requirement. In the Escalated 2 scenario, a level of retirements (15,618 MW) was assumed that resulted in meeting the 15.8% installed reserve margin reliability requirement and therefore no replacement resources were added.

Figure 3: Results: Escalated Retirements, Typical and Extreme Winter Load



In looking at more than 300 scenarios, it is clear that key elements such as availability of non-firm gas service, oil deliverability, pipeline design, reserve level, method of dispatch and availability of demand response become increasingly important as the system comes under more stress.

In particular, the combination of the following factors contributes to potential load loss events:

- The level of retirements and replacements
- The availability of non-firm gas service
- The ability to replenish oil supplies
- The location, magnitude and duration of pipeline disruption
- Pipeline configuration

While there is no imminent threat, fuel security is an important component of ensuring reliability – especially if multiple risks come to fruition. The findings underscore the importance of PJM exploring proactive measures to value fuel security attributes, and PJM believes this is best done through the competitive wholesale markets.

Next Steps

This document is intended as a summary of PJM's fuel security analysis and results. In December 2018, PJM will publish a paper on the analysis detailing the background, method, approach, analysis results, conclusions and next steps.

Results from the analysis were also reported in PJM's Nov. 1, 2018, Special Markets & Reliability Committee meeting. Based on these results, PJM will begin a stakeholder process to discuss potential solutions.

To continue stakeholder engagement, PJM will:

- Host a follow-up Special Markets & Reliability conference call on Nov. 26, 2018, to address additional questions that may arise as stakeholders review the study results.
- Host a Special Markets & Reliability meeting on Dec. 20, 2018, to discuss the additional detail provided in the paper.
- Introduce a Problem Statement and Issue Charge for stakeholder consideration in the first quarter of 2019 with any potential market rule changes targeted for filing with FERC in early 2020.

PJM will also continue to engage FERC in the national consideration of fuel security issues addressed in FERC's resilience docket.[10]

[10] https://www.pjm.com/-/media/documents/ferc/filings/2018/20180309-ad18-7-000.ashx