

**UNITED STATES OF AMERICA
BEFORE THE
DEPARTMENT OF ENERGY**

Codes, Standards, Specifications, and Other)
Guidance for Enhancing the Resilience of) FR DOC. 2019-14547
Electric Infrastructure Systems Against)
Severe Weather Events)

COMMENTS OF PJM INTERCONNECTION, L.L.C.

PJM Interconnection, L.L.C. (“PJM”) hereby submits comments on the United States Department of Energy’s (“DOE”) Notice of Request for Information (“RFI”) issued in the above-captioned proceeding on July 9, 2019. In the RFI, the DOE seeks “to gather ‘relevant consensus-based codes, specifications, and standards,’ state and industry best practices, and other pertinent materials to provide guidance for enhancing the physical and operational resilience of electric grid systems and their components, *e.g.*, generation, transmission, control centers, and distribution facilities, against (severe weather events, *e.g.* windstorms, floods, wildfires, etc.)”¹

I. COMMENTS

A. Introduction

PJM is a regional transmission organization (“RTO”) established with the approval, and subject to the regulatory jurisdiction, of the Federal Energy Regulatory Commission (“Commission”). PJM ensures the reliability of the electric transmission system under its functional control. In that role, PJM administers wholesale electricity markets and coordinates the transmission of electricity in and through the “PJM Region,” comprised of all or parts of thirteen states and the District of Columbia. PJM supports the DOE’s efforts to address concerns among government agencies, utilities and the

¹ RFI, Summary, *citing* the Disaster Recovery Reform Act of 2018 (Pub. L. 115-254).

public about risks presented by more frequent and more severe weather events with the purpose of addressing how to make electric infrastructure systems more resilient against such hazards, and how to do so effectively and at a reasonable cost.²

On March 9, 2018, PJM submitted extensive comments on this subject of grid resilience (“March 9 Comments”) in response to the Commission’s Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing Additional Procedures issued on January 8, 2018.³ PJM believes that the recommendations to further the resilience of the grid (a number of which already incorporate ‘best practices’ being utilized by PJM and others in the industry) represent an appropriate starting point and are attached herein as Appendix A.⁴

As a supplement to those recommendations, PJM offers the following comments responsive to the DOE’s requests and subject areas in the RFI.⁵

² *Id.*

³ *Grid Resilience in Regional Transmission Organizations and Independent System Operators*, 162 FERC ¶ 61,012 (2018) (“Grid Resilience Order”). In the Grid Resilience Order the Commission (1) terminated the proceeding regarding the proposed rule on Grid Reliability and Resilience Pricing submitted to the Commission by the Secretary of the United States Department of Energy that was focused on providing cost-of-service compensation to generators with on-site fuel capability, and (2) initiated a proceeding on Grid Resilience in Regional Transmission Organizations and Independent System Operators. The Grid Resilience Order directed each Regional Transmission Organization (“RTO”) and Independent System Operator (“ISO”), including PJM, to submit initial comments and responses to the Commission on resilience in order to enable the Commission to holistically examine the resilience of the bulk power system (hereinafter, RTOs and ISOs are referred to collectively as RTOs).

⁴ Although the Executive Summary is written with reference to recommended action by the Commission, the recommendations are equally applicable to the DOE RFI to the extent it seeks to model ‘best practices’ which can be employed around the nation.

⁵ PJM is addressing resilience as it relates to the Bulk Electric System (“BES”). The North American Electric Reliability Corporation (“NERC”) defines Bulk Power System as: (A) facilities and control systems necessary for operating an interconnected electric energy transmission network (or any portion thereof); and (B) electric energy from generation facilities needed to maintain transmission system reliability. The term does not include facilities used in the local distribution of electric energy. NERC defines Bulk Electric System as: “Unless modified by the lists shown below, all Transmission Elements operated at 100 kV or higher and Real Power and Reactive Power resources connected at 100 kV or higher. This does not include facilities used in the local distribution of electric energy...” (the detailed list of systems modifying the definition are not provided herein). *See Glossary of Terms Used in NERC*

B. Supply and Capacity Strategies

PJM's requirements and activities for both conservative operations and black start resource procurement are focused on identifying issues and potential solutions (market-based and otherwise) related to the availability of adequate generation assets to meet the demand requirements of weather-impacted operating conditions.

1. Conservative Operations

PJM Manual 13 allows PJM to position the generation fleet in the PJM Region to ensure the availability of capacity during periods when anticipated severe weather events threaten the operation of generation and transmission assets in the anticipated path of storms or in anticipation of extreme temperature conditions. Such conservative operations can be triggered by a number of events including wildfires and storms. For example, circumstances include nuclear facilities affected by extreme heat impacting cooling water discharge or forecasts that anticipate wind conditions or flooding that exceed operating thresholds forcing units off-line.

2. Reserve Scheduling (Internal and Cross-Regional)

Additional reserves are brought on-line to account for any predicted increase in forced outage rates associated with extreme weather or events. For example, under certain system conditions or events affecting either the electric or gas infrastructure, PJM will operate to reflect the impact of gas infrastructure contingencies (e.g., pipeline ruptures or compressor station failures) on the PJM region due to their potential impact on multiple natural gas generators. PJM staff has created procedures to ensure operators have a clearly defined process to address gas pipeline threats and contingencies that can

Reliability Standards, North American Electric Reliability Corporation (Jan. 31, 2018) (“NERC Glossary”), www.nerc.com/files/glossary_of_terms.pdf.

potentially impact the BES and required generation reserves. Moreover, PJM also evaluates with stakeholders lessons learned and performs after-the-fact simulations of actual events to ensure models, operating protocols, and reserve calculations, for example, are accurate and appropriate.⁶

PJM-internal assets can be augmented by reserve scheduling from neighboring ISO/RTOs that are not expected to be impacted by the same weather events (or expected to be impacted less severely). Today, in PJM's role as a NERC-registered planning authority and reliability coordinator, PJM coordinates with other RTOs, planning authorities and reliability coordinators for reliability as required by NERC. PJM's operating responsibilities include coordination and communications during emergencies with its neighbors, the Midwest Independent System Operator, Inc., Tennessee Valley Authority, New York Independent System Operator, Inc. ("NYISO"), and the VACAR companies through joint operating agreements.⁷

3. *Black Start*

As the Transmission Operator for the PJM Region, PJM works with the PJM Member Transmission Owners to procure sufficient black start resources to provide adequate cranking power during a possible system restoration event. As outlined in PJM

⁶ See PJM, *Technical Analysis of Operational Events and Market Impacts During the September 2013 Heat Wave* (Dec. 23, 2013), <http://www.pjm.com/-/media/library/reports-notice/weather-related/20131223-technical-analysis-of-operational-events-and-market-impacts-during-the-september-2013-heat-wave.ashx?la=en> ("2013 Hot Weather Report"); PJM, *Analysis of Operational Events and Market Impacts During the January 2014 Cold Weather Events* (May 8, 2014), available at <http://www.pjm.com/-/media/library/reports-notice/weather-related/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx> ("2014 Cold Weather Report"); PJM, 2015 Winter Report (May 13, 2015), available at <http://www.pjm.com/-/media/library/reports-notice/weather-related/20150513-2015-winter-report.ashx?la=en> ("2015 Winter Report").

⁷ See, e.g., *Joint Operating Agreement Between the Midcontinent Independent System Operator, Inc. and PJM Interconnection, L.L.C.*, § 8.1.9 (*Emergency Capacity or Energy*).

Manual 36, PJM seeks cross-zonal opportunities for cranking power to increase both reliability and efficiency. Such cross-zonal arrangements can be used to eliminate a black start shortage in a particular zone, meet critical load restoration timing requirements, improve restoration speed and efficiency, and reduce overall black start cost. Similar to the cross-zonal procurement process, PJM will also seek additional cross-zonal cranking path opportunities during a system restoration event based on system conditions.

4. *Gas/Electric Dependencies Fuel Security Study*

PJM has been improving its understanding of the circumstances associated with generation outages due to disruptions in interstate natural gas pipelines as a result of extreme weather. This includes utilizing tools such as incentives for installation of dual fuel generation through PJM's 'Capacity Performance' system of incentives and penalties for generator performance during defined Performance Assessment Hours and the leveraging of demand response on a sub-zonal basis to assist with meeting more localized contingencies.

On March 20, 2017, PJM issued a paper entitled "PJM's Evolving Resource Mix and System Reliability."⁸ This paper evaluates the changing resource mix in PJM given environmental regulations, the preponderance of low-cost natural gas, the increasing penetration of renewable resources and demand response, and the potential for retirements of nuclear power resources. Specifically, the paper examines whether the resource attributes necessary to maintain system reliability will continue to be available

⁸ PJM, *PJM's Evolving Resource Mix and System Reliability* (March 30, 2017), <http://www.pjm.com/-/media/library/reports-notices/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.Ashx?la=en> ("Fuel Report"); PJM, *Appendix to PJM's Evolving Resource Mix and System*

in sufficient quantities within various potential future resource portfolios. In addition, the paper raises questions about whether PJM should evaluate operating and planning for potential system events beyond those that drive traditional reliability criteria. More specifically, the paper questions whether there are additional objectives for system resilience that could be achieved by enhancing operational and planning procedures and requirements while taking into account actions PJM already has taken, such as implementation of Capacity Performance.⁹ PJM is presently reviewing those findings through its stakeholder process and also has engaged in additional ‘Phase 3’ discussions with policymakers and natural gas pipeline operators.

To advance resilience, PJM developed operating procedures that will define specific processes to evaluate the risk on the BES of natural gas infrastructure vulnerabilities, with a clear understanding of natural gas infrastructure redundancy including generator dual-fuel capabilities. Those procedures also will operationalize gas pipeline contingencies under normal operations and external threat conditions, such as cyber and physical threats. In support of these efforts, PJM has entered into specific information-sharing protocols with nine interstate natural gas pipelines and five local distribution companies serving customers in the PJM Region. Further, PJM has created a gas operations function that supports the PJM control room. PJM employees in the

Reliability (March 30, 2017), <http://www.pjm.com/-/media/library/reports-notice/special-reports/20170330-appendix-to-pjms-evolving-resource-mix-and-system-reliability.ashx?la=en>.

⁹ In April 2015, in an effort to address the risks of fuel security associated with individual generating plants, PJM revised how capacity resources were defined and compensated in the capacity market. The new capacity product, called Capacity Performance, incents generators to commit to more stringent performance requirements. This includes the “firming” of fuel supply (through firm gas service contracts, firm service contracts with greater flexibility or the installation of dual-fuel capability), as well as investment in operations and maintenance to shorten minimum run times and increase operational flexibility.

control room monitor natural gas pipeline conditions, and stay in regular communication with pipeline operators regarding changes to those conditions.

C. Infrastructure

PJM employs a number of efforts in its operations and planning reliability functions to address weather-impacted conditions resilience risk which go beyond PJM's reliability planning functions.

1. Cascading Tree Planning Analysis

PJM developed an in-house modeling tool to simulate the probability of outage cascades on the transmission system due to voltage collapse triggered by the loss of transmission lines or assets to extreme events. This allows for contingency analysis of planned transmission outages or proposed transmission construction to determine the potential for increased risk of cascade based on existing transmission assets beyond the required reliability analysis.

This tool allows PJM to simulate severe contingency events, such as the loss of a substation at extreme conditions by utilizing an “*n-k*” analysis, which represents losing a number of lines and transformers, in this case *k*. With the loss of lines and substations, certain amounts of load and generation will be lost and other lines will overload and trip. All of the subsequent events are based on probabilities and assumptions that we must make as an operator. This allows for hypothetical testing where PJM can apply the model and map segments of the transmission system to determine what area is likely to have a black out with corresponding probabilities of occurrence. Using this tool PJM can assess 3 variables, 1) Probability of a system cascading, 2) Anticipated load and generation loss, and 3) Whether the cascade is bounded or unbounded/unstable.

Additionally, by overlaying a “Monte Carlo” analysis, PJM can identify the infrastructure that is most vulnerable to cascades or lines/substations that are impacted more frequently and reinforce those facilities. Beyond extreme events, PJM can use this tool to compare competing transmission projects to measure which one increases or decreases the probability of cascading or resilience.

2. *Robust Long-Term Planning to Create Secondary Cranking Paths for Black Start Service to Critical Loads and Reducing the Number of Critical Substations*

PJM is also reviewing black start plans to include pre-planned paths for alternate flows in the event that primary cranking paths are damaged, compromised or otherwise disrupted to ensure critical load requirements are met. Resilience vulnerabilities that are significant enough to warrant a transmission system enhancement designed specifically to mitigate the vulnerability could be designed and integrated into the Regional Transmission Expansion Plan. Examples of this can include building redundancy into black start cranking paths, ensuring that any new transmission infrastructure does not exacerbate the criticality of substations and supporting transmission owner efforts to mitigate substations that are classified as critical under NERC reliability standard (CIP-014), and power flow diversity for areas with load congestion or high concentrations of critical restoration units.

D. Operations

As the Transmission Operator for its Transmission Operator Area,¹⁰ PJM engages in various strategies to advance grid resilience.¹¹ For example, PJM employs a strategy

¹⁰ The NERC Glossary defines Transmission Operator as: “The entity responsible for the reliability of its “local” Transmission System, and that operates or directs the operations of the Transmission Facilities.”

which involves an examination of vulnerabilities, often employing industry or technology best practices to take operational precautionary steps to mitigate the vulnerability including “Max Emergency” dispatch. PJM is also pursuing a strategy raising awareness, sharing information regarding vulnerabilities, and initiating collective institutional efforts such as PJM’s work on enhanced communication solutions to address weather related vulnerabilities.

1. *“Max Emergency” Dispatch Procedures*

PJM developed as part of the Fuel Security Study “Max Emergency” dispatch procedures to account for the circumstances where PJM would dispatch generation purely for reliability and not for economics in order to avoid a planned load shed. The example highlighted in the “PJM’s Evolving Resource Mix and System Reliability” study was instructing generators to continue burning their primary fuel source (natural gas) even though it is more expensive than their secondary fuel source (oil), because the resupply rate of oil will not sustain operations for an extended period of time without access to natural gas.¹²

2. *Emergency Communications*

PJM is engaged in an effort as part of the Electric Subsector Coordinating Council (“ESCC”) Research and Development Committee Co-Chaired by the CEO of PJM and the CEO of the New York Power Authority (“NYPA”). A Resilient Communications Working Group was formed to determine the technical and operational viability of

Transmission Operator Area is defined as: “The collection of Transmission assets over which the Transmission Operator is responsible for operating.”

¹¹ See e.g. Klinke, A. and Renn, O. (2002). A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based, and Discourse-Based Strategies. *Risk Analysis* 22(6).

¹² See PJM Manual 13, section 3.3.

alternate communication technologies to meet the voice connectivity requirements of essential grid functions following a major disruption with minimal or no dependence on ground-based commercial telecommunications infrastructure. This would allow for the execution of essential functions like voice links between primary control centers of PJM and Transmission Owners to regain basic system visibility following a major weather event that disrupts primary communication systems. A technical demonstration of this communication technology is scheduled for October 25, 2019, with participation from PJM, NYPA, Southern Company, the NYISO, Duke Energy, Dominion Energy, and Hydro One Quebec. This industry-funded, voluntary program is managed by the Electric Power Research Institute (“EPRI”) and is expected to be implemented in a pilot format in 2020.

E. Department of Defense Initiative

PJM is partnering with applicable load serving entities and the Office of the Secretary of Defense (“OSD”) for Mission Assurance to develop a regional critical load assessment for non-black-start assets to support the energy resilience requirements of the U.S. Department of Defense installations within the PJM Region. This analysis is designed to identify “retail” loads with a higher level of criticality than standard customers due to the importance of the operational functions they support or the anticipated impact of an extended outage of their facility on interdependent infrastructure systems that rely on their availability. By identifying loads of this type, the transmission and generation assets supporting these locations and customers can be evaluated for infrastructure hardening, transmission path redundancy, and fuel-secure capacity with tailored operating capabilities to ensure the continued deliverability or rapid restoration

of service to these critical loads at a regional scale. This effort is being undertaken with load serving entities who maintain the retail obligation to serve these Department of Defense facilities.

II. CONCLUSION

PJM respectfully requests that the DOE consider the foregoing comments in this proceeding.

Respectfully submitted,

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APPENDIX A

PJM's March 9 Comments' executive summary is as follows:

In its broadest sense, resilience involves preparing for, operating through, and recovering from events that impose operational risk, including but not limited to high-impact, low-frequency events. However, resilience is not only about high-impact, low-frequency events. Rather, resilience also involves addressing vulnerabilities that evolved over time and threaten the safe and reliable operation of the BES (or timely restoration), but are not yet adequately addressed through existing RTO planning processes or market design. Many of the actions, policies, procedures, and market structures designed to improve system resilience are scalable and applicable to a wide range of potential risks and impacts. The challenge lies in the nature of high-impact, low-frequency events, because they are not amenable to quantitative, probability-based analyses commonly used for risk management¹³ due to the difficulty of predicting the timing and impact of their occurrence. Probabilities of high-impact, low frequency events are generally unknown or extremely difficult to quantify, and the consequences or impacts of high-impact, low-frequency events - although assumed to be intolerably high in terms of both human and economic costs - are difficult to quantify. Prudent resilience efforts to address verifiable vulnerabilities and threats are worthwhile despite the uncertainty, and can be effectively and efficiently managed through the use of a range of complementary analyses and strategies.

Accordingly, PJM requests that the Commission take the following actions to enhance resilience of the grid and interrelated systems that depend on the BES.

- Finalize through this proceeding a working definition and common understanding of grid resilience, clarifying that resilience resides within the Commission's existing authority with respect to the establishment of just and reasonable rates, terms and conditions of service under the Federal Power Act ("FPA").
- Establish a Commission process, either informally through one or more of the Commission's existing offices, or formally through a filing process, that would allow an RTO to receive verification as to the reasonableness of its assessments of vulnerabilities and threats, including Commission utilization of information that may be available to it, but not available to the RTO because of national security issues. Those assessments, once verified, could then form the basis for RTO actions under its planning or operations authority consistent with its tariffs. Simply put, in coordination with other federal agencies such as the United States Department of Defense ("DOD"), DOE, United States Department of Homeland Security ("DHS"), as well as NERC, the Commission needs to provide intelligence and metrics to apply to resilience vulnerability and threat analyses that can

then guide and anchor subsequent RTO planning, market design, and/or operations directives.¹⁴

- Articulate in this docket that the regional planning responsibilities of RTOs currently mandated under 18 CFR § 35.34(k)(7), and the NERC TPL standards (which among other things require RTOs to plan to provide reliable transmission service and assess Extreme Events to the BES), includes an obligation to assess resilience. The Commission should consider, after confirming that resilience is a component of such planning, initiating appropriate rulemakings or other proceedings to further articulate the RTO role in resilience planning including affirmative obligations and standards to plan, prepare, mitigate, etc. As part of this effort, the Commission should reconcile its continued interest in transparency in planning processes under Order Nos. 890 and 1000 with the challenges of public disclosure of significant grid resilience vulnerabilities. Working with stakeholders, PJM has begun this process to include existing standards like NERC CIP-14 critical facilities and urges the Commission to provide assistance to ensure that the goals of transparency and information to end users do not become a means to disclose grid vulnerabilities that can be exploited by those with bad intent.
- Require that all RTOs (and jurisdictional transmission providers in non-RTO regions) submit a subsequent filing, including any necessary proposed tariff amendments, to implement resilience planning criteria, and develop processes for the identification of vulnerabilities, threat assessment and mitigation, restoration planning, and related process or procedures needed to advance resilience planning.
- Request that all RTOs (and jurisdictional transmission providers in non-RTO regions) submit a subsequent filing, including any necessary proposed tariff amendments, for any proposed market reforms and related compensation mechanisms to address resilience concerns within nine to twelve months from the issuance of a Final Order in this docket. PJM, together with its stakeholders, is already actively evaluating such potential reforms that advance operational characteristics that support reliability and resilience, including (i) improvements to its Operating Reserve market rules and to shortage pricing, (ii) improvements to its Black Start requirements, (iii) improvements to energy price formation that properly values resources based upon their reliability and resilience attributes, and (iv) integration of distributed energy resources (“DERs”), storage, and other emerging technologies. A deadline for submission of market rule reforms that the RTO feels would assist with its resilience efforts would help ensure focus on these issues in the stakeholder process.
- Request that PJM submit a subsequent filing, including any necessary proposed tariff amendments, to permit non-market operations during emergencies, extended periods of degraded operations, or unanticipated

restoration scenarios. Such filings could including provisions for cost-based compensation when the markets are not operational or when a wholesale supplier is directed to take certain emergency actions by PJM for which there is not an existing compensation mechanism.¹⁵

- Establish improved coordination and communication requirements between RTOs and Commission-jurisdictional natural gas pipelines to address resilience as it relates to natural gas-fired generation located in RTO footprints. With respect to interstate pipelines, PJM respectfully requests that the Commission launch additional initiatives addressing the interaction between RTOs and interstate natural gas pipelines as follows:
 - PJM supports additional reforms to Order No. 787 to avoid the variable levels of information sharing provided by different pipelines in the PJM Region that resulted from the strictly voluntary nature of Order No. 787.
 - PJM requests additional efforts by the Commission to encourage sharing of pipelines' prospective identification of vulnerabilities and threats on their systems and, sharing on a confidential basis in real-time, the pipeline's modeling of such contingencies and communication of recovery plans. This would ensure that the RTO has the best information in real-time to make a determination whether to increase Operating Reserves or take other emergency actions in response to a pipeline break or other contingencies occurring on the pipeline system. Although a degree of effective coordination and communication with the pipelines serving the PJM Region has been achieved, more of a focus on real time coordination of modeling of contingencies and real-time communication of same would ensure greater consistency in coordination and information and can bring gas/electric coordination, to the next level to face the next generation of resilience issues. Accordingly, PJM recommends a more holistic regulatory framework for identifying and coordination of modeling of (1) pipeline contingencies in RTO planning and (2) real-time impacts of adverse pipeline events on BES operations.
 - PJM requests an increased focus on restoration planning coordination between RTOs and pipelines as each entity has valuable information that can affect the other's timely restoration.
 - PJM urges the Commission to encourage the development of additional pipeline services tailored to the flexibility needs of natural gas-fired generation so as to encourage appropriate tailoring and pricing of services beyond today's traditional firm/interruptible paradigm.

- PJM believes that much can be done both in the Commission’s exercise of jurisdiction over RTOs as well as interstate pipelines to improve generation interconnection coordination with pipelines in order to better align interconnection activities and timelines and minimize potential issues associated with generation facilities located in areas on pipeline systems where reliability or resilience benefits may be sub-optimal.
- Finally, PJM believes that more action is needed to support the harmonization of cyber and physical security standards between the electric sector and the natural gas pipeline system. PJM recognizes that this matter spans beyond the Commission but also involves the Transportation Security Administration (“TSA”) and Pipeline and Hazardous Materials Safety Administration (“PHMSA”), but believes that through greater inter-agency coordination, a base level of resilience to physical and cyber-attacks can be achieved even while still respecting the different regulatory authorities of each agency.
- In addition, greater communication and coordination is needed with the local distribution companies (“LDCs”) that supply wholesale generation, and the Commission should support such efforts including evaluating whether communication and coordination obligations should be imposed on LDCs that supply jurisdictional wholesale generation.¹⁶
- As noted below, PJM is moving forward on requiring dual fuel capability at all Black Start Units but urges, as the next step, coordination across the nation of a consistent means to determine Critical Restoration Units and the development of criteria to assure fuel capability to such Critical Restoration Units.¹⁷
- RTOs, as part of their restoration role, should be asked to demonstrate steps they are taking to improve coordination with other critical interdependent infrastructure systems (*e.g.*, telecommunications, water utilities) that (i) could be impacted through events of type discussed herein, or (ii) are themselves vulnerabilities that could contribute to, or amplify the impact of such events. Coordination between the Commission, the Federal Communications Commission (“FCC”) and DHS would provide additional federal support for such efforts.