



United States Senate

Committee on Energy and Natural Resources

Testimony of Andrew L. Ott, President & CEO
PJM Interconnection, L.L.C.

"An Examination of Blackstart, the Process
for Returning Energy to the Power Grid after
a System-Wide Blackout, and other System
Restoration Plans in the Electric Utility
Industry"

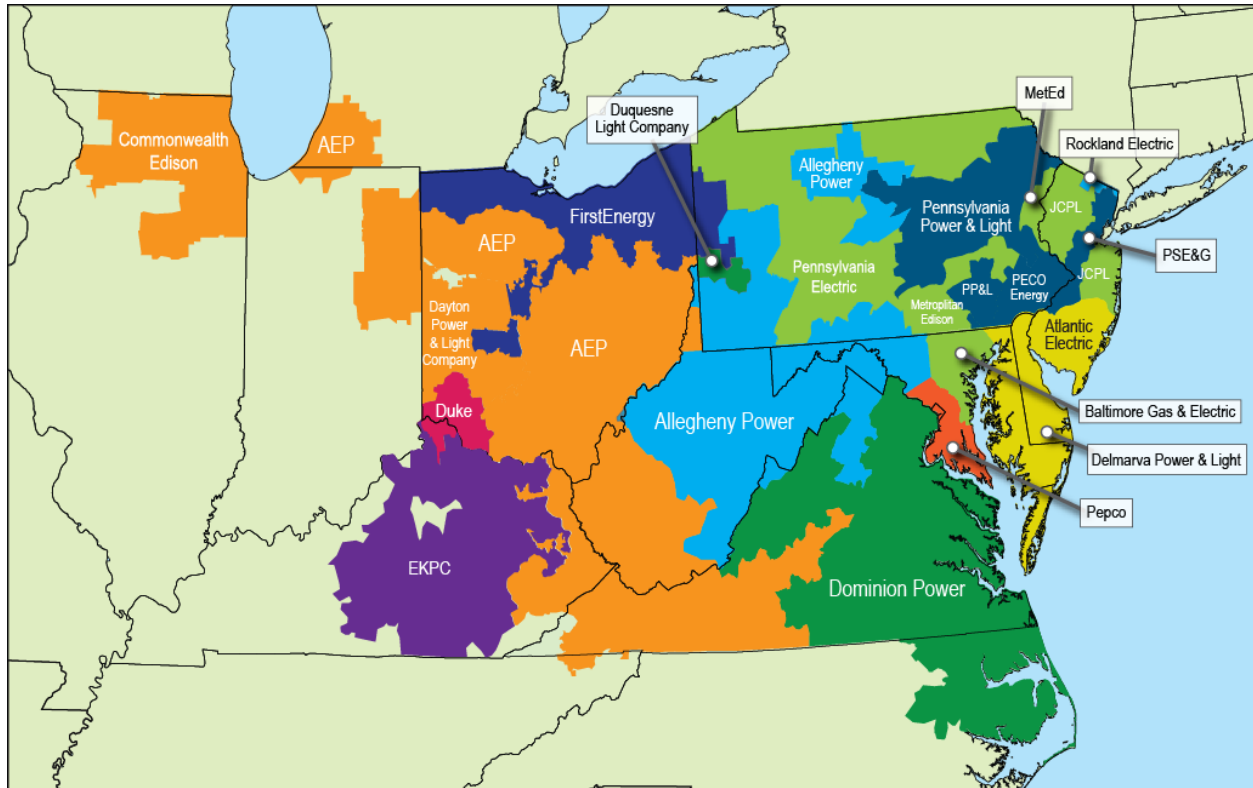
October 11, 2018

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President & CEO
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Thank you for the opportunity to testify today. I am Andrew Ott and serve as President and CEO of PJM Interconnection. PJM is the regional transmission organization responsible for the reliable operation of the bulk electric power grid serving 65 million people in all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia. PJM operates the largest bulk power system in the nation, and serves almost a quarter of the country's electricity needs.



Before I begin today, I want to acknowledge the hard work of the staff of Dominion Energy and Duke Energy, two PJM members, as they worked to restore power lost as a result of Hurricane Florence in North Carolina.

The eastern shore of North Carolina is in the PJM service territory. While this effort was primarily led by the local utilities, we coordinated closely with these affected PJM members and appreciate all of the effort by the industry as a whole to continue to make sure reliability and prompt service restoration are the first priority.

I. Introduction and Overview

I want to lead off today with some key points for your consideration:

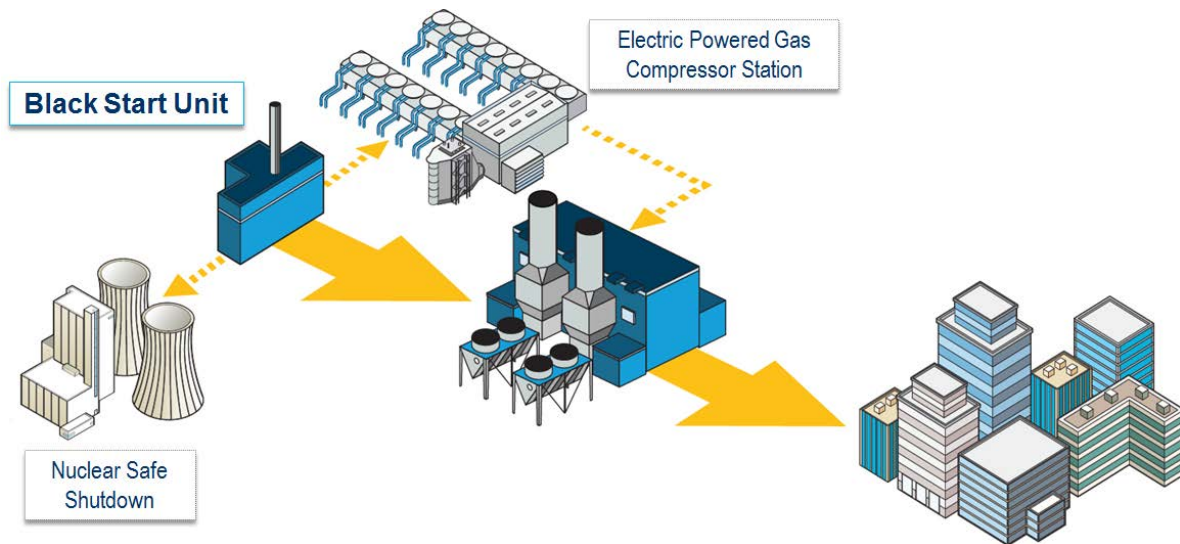
- **Reliability and Effective Restoration of Service Are the Top Priorities for a Grid Operator:** Restoration of service in response to natural disasters as well as potential physical or cyberattacks is not a new task for PJM or any other system operator. We have established processes and procedures in place, and working with the individual utilities in our region as well as with our neighbors, we drill for these events continuously.

Restoration is a key part of our reliability responsibilities at PJM and is something we take extremely seriously.

- **Restoration of Service Is a Shared Responsibility:** Restoration of service is a shared responsibility among local utilities, regional transmission organizations (RTOs) such as PJM, and end-use customers, as well as the federal government and state and local authorities.

There are three key aspects of the important task of recovering from a disruption and restoring service to customers, including special roles assigned to the federal government and the states:

1. **Restoration of Critical Loads:** One of PJM's key roles is to ensure service to key strategically located generators, known as black start resources, which can start without needing to draw power from the grid. These quick-start resources are then utilized to energize transmission lines and restart other generators, which in turn are needed to restart other generators needed to restore the grid and ultimately get customers back online. The black start resources also provide safe shutdown power for nuclear units and ensure service to critical natural gas facilities needed to fuel larger generators during the restoration process. We refer to this as restoration of critical loads.



2. **Priority Restoration to Key End-Use Facilities:** Local utilities and the states play key roles in prioritizing restorations at the distribution level to hospitals, National Guard facilities, critical communication equipment and other locations critical to public health and safety. The specific priorities and plan for each utility are often described in tariffs and regulations adopted and overseen by state public utility commissions.
3. **Individual Customer Backup Generation:** In addition to these systemwide efforts, a number of end-use customers, including Department of Defense facilities and others, also invest in their own backup generation. This is often referred to as “behind-the-meter” generation. PJM is working on improving visibility of and communication to these behind-the-meter resources in order to take them into account in our own restoration plans and, with the customer’s consent, to be able to dispatch any excess capacity from these resources to meet the needs of others. We refer to this as enhancing the visibility and dispatchability of these individual customer resources and it is a combined effort with key end-use facilities in our region such as military bases.

- **Restoration of Systems from a Cybersecurity Event Requires Enhanced Coordination and Redundancy:** Threats like electromagnetic pulses and cyberattacks require us to look at restoration

differently than severe weather, given their ability to impede traditional restoration activities by targeting the tools and systems we use to operate and restore the grid. While a cyberattack could cause an outage requiring black start, the presence of an active adversary and the extent of a cyber intrusion can affect the availability of the industrial control system (ICS) and supervisory control and data acquisition (SCADA) tools the industry uses to remotely execute black start and other vital grid functions. Therefore, industry and government continue to evolve to consider new threats that may require more advanced methods to restore the system following an outage that also account for communications and data disruptions stemming from a targeted attack. This includes work on redundant communications systems, joint training between industry and government cyber-response capabilities and updates to black start plans to add operational flexibility.

All of the above aspects of recovering from a disruption and restoring service are important considerations for the reliable provision of electricity, and supporting interdependent critical services, and are the focal points of PJM's near-term resilience activities. All of these efforts work together to ensure timely service restoration.

Action Steps Going Forward

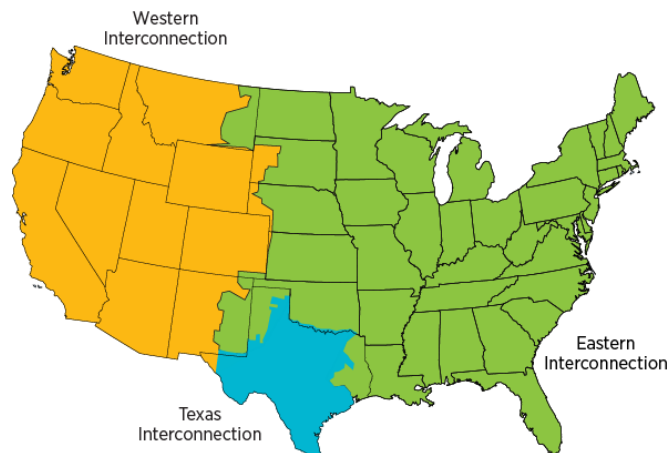
Ensuring a Resilient Grid: PJM is working to ensure that the grid, which is reliable today, is also resilient when faced with new levels of cyber and physical threats. This too is a responsibility that is shared, with key roles for the Federal Energy Regulatory Commission (FERC), the Department of Energy, the Department of Homeland Security, PJM, our member companies, and state and local public officials. The grid is reliable today and will continue to be into the future. The goal of our resilience efforts is to ensure that the grid can withstand prolonged outages from events that pose risks beyond what is covered by today's reliability standards.

Encouraging Interagency Coordination: It remains critical that the various agencies of the federal government approach this issue in an organized, cohesive fashion. Although much coordination occurs today among FERC, the Department of Energy and the Department of Homeland Security, additional work is needed and appropriate to bring in and harmonize the work of other key agencies. These include the Transportation Security Administration, which is responsible for overseeing the physical security and cybersecurity of the gas pipeline system, and the Federal Communications Commission, which plays a critical role in allocating spectrum to enable key communications in the event of an extended outage. This effort requires intergovernmental coordination and was a recommendation we highlighted prominently in our comments to FERC in our reply to the Docket No. AD18-7-000, "Grid Resilience in Regional Transmission Organizations and Independent System Operators." I have included the executive summary of our recommendations to FERC of specific resilience action steps it could take in the attachment to my testimony.

II. Defining Terms

The term "black start" is often misunderstood. Since the Eastern, Western and Texas Interconnections are, in essence, three large synchronous machines, a system outage caused by a downed transmission line or voltage collapse on one part of the grid can often be isolated through the use of relays and circuit breakers. In such instances, system restoration is accomplished by carefully resynchronizing the isolated grid to the rest of the grid.

Restoration of the grid from a black start condition occurs when an entire interconnection (Eastern, Western or Texas) is down, and there is no other part of the interconnection that is available to connect in order to synchronize the isolated part of the grid to the rest of the operating grid. In such an instance, we call on black start resources, which are generators



strategically located at key points on the grid that are able to start without the help of electric power in order to start other generators and natural gas compressor stations that are dependent on electric power. As those generators in turn are energized and synchronized to the grid, they restore power to other generators, which results in restoration of service to end-use customers.

Although we procure black start resources and test them regularly, I am pleased to report that PJM has never had to call upon these resources to operate in a restoration event. This is because we have not, to date, experienced an interconnection-wide outage that has prevented us from “jump-starting” one part of the grid by synchronizing it with another part. Nevertheless, the service is critically important, and procuring sufficient black start resources is a responsibility we take seriously.

III. The Impact of Retirements of Nuclear and Coal Resources

Discussion around ensuring adequate black start resources is a different discussion from the important focus we have had on recent announced retirements of nuclear and coal resources. Black start units are, by definition, small, quick-start resources that can energize very quickly and otherwise may operate quite infrequently. For this reason, natural gas combustion turbines are currently the technology of choice for black start, although strategically placed batteries are an emerging promising black start technology. As to the interaction of nuclear units to black start units, we use black start resources to ensure the safe shutdown of nuclear facilities — not to re-energize those resources back onto the grid after a shutdown. Synchronizing a nuclear unit back onto the grid after a loss of part or all of the grid is a more complex process that requires potential Nuclear Regulatory Commission review and a time for the unit to ramp back to full production levels.

IV. Looking Forward: The Role of Resilience Planning as It Affects System Restoration

Although, as outlined above, black start is a distinct service, PJM’s activities to ensure a resilient grid have also taken a larger focus. After the 2014 Polar Vortex, with the support of FERC, we made significant changes to enhance the performance of the generation resources on which we rely. This initiative, known as Capacity Performance, has led to a noticeable improvement in generation fleet performance, as we detailed in our 2018 white paper “Strengthening Reliability: An Analysis of Capacity Performance.” As noted in that analysis:

“During the cold snap of 2017–18, Capacity Performance resources’ forced outage rates were significantly lower than during the 2014 Polar Vortex (5.5 percent vs. 12.4 percent). Other indicators of the effectiveness of Capacity Performance include improvements of over 50 percent in many operating parameters after the implementation of Capacity Performance, such as a decrease in restrictive generator operating parameters, reported investment in major reliability work for existing resources, and new resources investing in firm gas and transportation contracts.”

In early 2017, we issued a fuel analysis paper, “PJM’s Evolving Resource Mix & System Reliability,” which concluded that the PJM system can remain reliable with the addition of more natural gas and renewable resources, but that heavy reliance on any one resource type raises questions about electric system resilience beyond existing reliability standards.

We are currently embarking upon a detailed fuel security analysis that builds on our past work by looking beyond reliability to the ability of the grid to withstand extreme events of extended duration. Our analysis will consider the advantages and disadvantages of each fuel type during extended events, recognizing the impact of the increased penetration of natural gas and renewable resources as nuclear and coal generation resources retire.

Although our conclusions will be released shortly, I can observe two key points so far:

- **Resilience Issues Are Location-Specific.** An electric generator sitting virtually on top of shale gas wells is potentially as fuel secure as a coal plant with an adjacent coal pile or a nuclear facility with fuel rods on-site. On the other hand, a natural gas generator without dual fuel and served off of a single lateral natural gas line is clearly not as resilient. As in real estate, "location matters."
- **Policymaking Guidance Is Needed:** As with any exercise of this sort, there is a balance that policymakers will need to strike. We need to ensure the grid is resilient to extreme but plausible events and need to decide the degree of resilience investment that is reasonable for the ratepayers of the region to bear. The ratepayers of our region, be they households or businesses, shouldn't be responsible for securing the grid from a World War III type of attack. At some point, that becomes the task of national defense, paid for by taxpayers across the land. On the other hand, once we issue the results of our analysis, we intend to work with stakeholders to consider how best to value fuel security beyond the initiatives we have already undertaken through our Capacity Performance construct. Nevertheless, PJM cannot do this alone. As noted previously, we proposed 10 specific recommendations to FERC of concrete steps that can be taken to provide that critical guidance. We respectfully await their action on those initiatives and other related issues.

PJM has worked to serve as a resource to this Committee on a host of issues, ranging from questions associated with reliability to the operation of our markets. We pledge to continue to serve in that role as you weigh these important national policy issues.

Thank you again for this opportunity, and I look forward to your questions and comments.

Attachment: Recommendations of Specific Resilience Action Steps from PJM Interconnection Response to FERC Grid Resilience Proceeding

**UNITED STATES OF
AMERICA BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION**

**Grid Resilience in Regional Transmission
Organizations and Independent System
000 Operators**)
)
) **Docket No. AD18-7-**
)

**COMMENTS AND RESPONSES OF PJM INTERCONNECTION,
L.L.C.**

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March 9, 2018

**UNITED STATES OF
AMERICA BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION**

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Grid Resilience in Regional Transmission)	
Organizations and Independent System)	Docket No. AD18-7-
000 Operators)	
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COMMENTS AND RESPONSES OF PJM INTERCONNECTION, L.L.C.

PJM Interconnection, L.L.C. (“PJM”) hereby submits its comments and responses (“Comments”) to the resilience issues and inquiries identified in the Federal Energy Regulatory Commission’s (“Commission”) Order Terminating Rulemaking Proceeding, Initiating New Proceeding, and Establishing Additional Procedures issued on January 8, 2018.¹ Through these Comments, PJM:

- outlines the considerable steps PJM and its stakeholders have undertaken, or have actively underway, to enhance the resilience of the portion of the Bulk Electric System² (“BES”) operated by PJM, and

¹ *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 (“DOE”) that was focused on providing cost-of-service compensation to generators with on-site fuel capability, and (2) initiated the above-captioned 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.

² In its questions, the Commission referenced the resilience of the bulk power system. In its responses, PJM is addressing resilience as it relates to the Bulk Electric System. 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*

- details specific action steps the Commission (in some areas working with other federal and state agencies) could undertake to enhance overall resilience of the BES not just in the PJM Region but potentially across the nation.

Just as with so many issues before the Commission, enhancing grid resilience requires a careful balancing of many competing interests. Ultimately, the goal is to ensure that the BES can continue, into the future, to meet the needs of customers for the reliable and secure delivery of electricity at a price which remains just and reasonable. PJM has approached these Comments by striving to balance those different concerns and interests.

I. INTRODUCTION

There are a number of important initiatives that are underway and others that should be enhanced and made part of the Commission's focus with respect to system resilience. Defining resilience is an important first step as outlined below. Addressing the issues raised in the Commission's inquiries to the RTOs is an important second step.³

As a multi-state RTO, PJM has visibility into interstate and inter-system resilience vulnerabilities and restoration challenges. PJM's role in the resilience effort is not an exclusive role, but a partnership role that involves interaction and coordination with member Transmission Owners,⁴ Load Serving Entities, end-use customers, the Commission, other federal and state agencies and regulatory commissions, and other stakeholders. But given the interconnected nature of the electric power grid, there is an important federal interest that must be recognized and advanced in addressing resilience. As a result, as proposed herein, the Commission should

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

³ Although PJM is supportive of this docket starting with an inquiry to the RTOs, grid resilience issues are not limited to RTOs. If anything, because of their scale and scope, RTOs are best able to evaluate overall grid resilience issues of the BES in their footprints. But the scope of the Commission's effort should in no way be limited to RTOs since many if not most BES grid resilience issues are truly national in scope.

⁴ All capitalized terms that are not otherwise defined herein have the meaning as defined in the PJM Open Access Transmission Tariff ("Tariff"), Amended and Restated Operating Agreement of PJM Interconnection, L.L.C. ("Operating Agreement"), and Reliability Assurance Agreement Among Load Serving Entities in the PJM Region.

advance additional processes that could help with additional coordinated identification, authentication and mitigation of future grid resilience challenges, and authentication and mitigation of the vulnerabilities that currently exist.

To be clear, the PJM BES is safe and reliable today – it has been designed and is operated to meet all applicable reliability standards. However, improvements can and should be made to make the BES more resilient against known and potential vulnerabilities and threats. In many cases, resilience actions are anchored in, but go beyond what is strictly required for compliance with, the existing reliability standards. As a result, PJM has identified a number of recommended initiatives.

II. EXECUTIVE SUMMARY

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 management⁵ 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-

⁵ See e.g. Kaplan, S. and Garrick, B.J. (1981). On the Quantitative Definition of Risk. *Risk Analysis* 1(1).

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").⁶
- 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.⁷
- 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

⁶ See, e.g., Section 215, 16 U.S.C. §824o.

⁷ Through this process, PJM would be seeking verification that its vulnerability identification or threat assessment is consistent with information (including classified information not necessarily available to PJM) held by the federal government and thus should be used to guide future actions. The verification would be solely of the identified vulnerability or assessed threat and would not preclude challenges in the context of a rate proceeding or otherwise as to the cost efficiency of addressing the vulnerability or threat.

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 include 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.⁸
- 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

⁸ Any such RTO procedures would be limited, and would not interfere with DOE emergency actions under FPA, sections 202(c) or 215A. 16 U.S.C. §§ 824a(c), 824o-1.

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.⁹
- 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.¹⁰
- 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.

PJM stands ready to work with the Commission and its stakeholders on each of these potential initiatives, and appreciates the Commission’s leadership in this important area.