U.S. Senate Committee on Energy and Natural Resources

March 11, 2021 Hearing: The Reliability, Resiliency and Affordability of Electric Service in the United States Amid the Changing Energy Mix and Extreme Weather Events

Questions for the Record Submitted to Mr. Manu Asthana

For Public Use

Questions from Chairman Joe Manchin III

Question 1: Extreme weather events, physical attacks, and cyber-attacks are occurring more frequently. We must continue to make the infrastructure of our nation reliable, resilient, and responsive, but we must also have the ability to recover from the loss of service and loss of equipment as expeditiously as possible.

a. **Do you believe that it is prudent to require utilities to have executable plans that outline how they would recover from a catastrophic event and require that plan to incorporate best practices used by other industries, as well as include a reserve of equipment that is readily available and dedicated to these events?**

PJM Response: We at PJM fully concur with the need not only to maintain a reliable and resilient infrastructure but also to have in place plans to recover and restore a functioning grid as soon as possible.

Within the PJM region, recovery plans for such eventualities already exist and are practiced on a regular basis. Specifically, PJM memorializes in its Manual 13 (*Emergency Operations*) our detailed plans for operating the system in response to a number of different grid emergencies including capacity shortages, extreme weather events, geomagnetic disturbances, sabotage or terrorism emergencies, and transmission security emergencies. In addition, PJM maintains in its Manual 36 (*System Restoration*) a detailed recovery plan in response to loss of all or portions of the grid. The plan centers on restoration of the bulk power electric grid in response to one of these events and includes specific provisions concerning communications during an emergency to the public and certain government agencies [e.g., the Federal Emergency Management Agency, the Department of Energy, the North American Electric Reliability Corporation (NERC), and state public utility commissions]. The PJM manuals were developed with the endorsement of PJM stakeholders who, as a stakeholder body, encompass all aspects of the industry from generation and transmission owners to customers within the PJM region.

Complementing that plan, individual distribution utilities have restoration plans. Those plans address priorities for restoration of particular customer classes and also address emergency communications. These plans are also coordinated with state emergency management agencies and are practiced through organized drills on a regular basis.

The industry has also worked extensively to address the need for reserves of critical equipment that would be needed as part of a grid restoration. For example, the industry – with PJM support – created banks of spare transformers to be available in emergencies. Considering the size and specialized construction needed for transformers, absent this bank of spare transformers, replacement of this asset could take months.

For example, the North American Transmission Forum's Regional Equipment Sharing for Transmission Outage Restoration (RESTORE) program, identifies an inventory of designated spare equipment to be called upon only after a particular type of "triggering event." Under the program, a triggering event is an event that:

- Is catastrophic in nature; and
- Creates an urgent grid need in which, for an extended period, the affected utility loses its ability to serve significant load; or
- Represents a risk that a participating transmission owner could, in the near future lose its ability to serve significant load levels or is otherwise unable to maintain grid stability.

PJM's transmission owners participate in this and other similar programs, or maintain their own inventory of spare transformers, and work with PJM to help identify the spare critical equipment needed for such programs.

PJM will also assess the reliability risk associated with lower voltage transformers and the potential need for additional spare transformers. If risks are identified, PJM may perform an analysis similar to the probabilistic risk analysis performed for the 500/230 kV transformers.

PJM recognizes these Transmission Owner efforts. However, PJM notes that there are additional resilience actions that deserve further consideration by policymakers. On March 9, 2018, in FERC Docket No. AD18-7-000, PJM filed over 15 specific recommendations with the Commission that would enhance the resilience of the grid. A copy of the Executive Summary of PJM's comments is attached. Although that docket has been closed by the Commission, PJM looks forward to working with the Commission, states and stakeholders on these important resilience issues through the Commission's recently opened docket on Climate Change, Extreme Weather and Grid Reliability Docket No. AD 21-13.

Question 2: A report released last week by ICF International claimed that U.S. utilities may have to invest more than an additional $500 billion in the next three decades to safeguard critical energy systems against damage from extreme weather. This "resilience gap" is driven largely by the need to harden infrastructure against the effects of climate change, including heat waves, extreme storms, sea-level rise, and wildfires.

a. **How are you monitoring the impacts of climate change on your system?**

b. **How are you incorporating those findings into your system planning?**

PJM Response: Because of the exposed nature of electric infrastructure to severe weather conditions, PJM closely monitors both short- and long-term weather patterns. PJM has on staff a full-time meteorologist for the purpose of monitoring weather conditions as they affect grid operations.

PJM also addresses catastrophic events in planning and operations, which could include a catastrophic event caused by extreme weather or climate change. Extreme weather events from climate change could manifest itself through the atypical loss of generation, transmission and natural gas pipelines or an atypical combination thereof. PJM's operations and planning studies, and NERC reliability standards, address the

atypical loss of generation, transmission and natural gas pipelines that may result from extreme weather events, among others.

For example, under NERC reliability standard TPL-001-4, PJM staff annually studies extreme events to evaluate their impact on the transmission system. An extreme event is defined as having a reasonable possibility of occurring and of being outside the normal types of events studied in TPL-001-4. Under PJM's process, an analysis is performed annually for a near-term (year one through five) study by a current five-year-out Regional Transmission Expansion Plan (RTEP) case, which shows system performance following an extreme event contingency as listed in Table 1 of TPL-001-4. This analysis includes a review of impacts to existing and planned facilities, as well as all projected firm transfers of electricity consistent with the corresponding RTEP case. Reactive power resources are included consistent with the corresponding RTEP case to ensure that adequate reactive resources are available to meet system performance. All effects of existing and planned protection and control devices including backup and redundant systems are also studied. This study assesses the impact of the extreme events that are identified as required in the NERC TPL-001-4 reliability standard.

While PJM does perform extreme event analysis under TPL-001-4 and incorporates the results into the RTEP process, the standard itself does not require the reinforcement of the system to mitigate this risk. Moving forward, the industry may want to explore methods to perform this analysis in a Monte Carlo simulation to examine which facilities are most at risk from extreme events and more susceptible to cascading, instability or separation and consider mitigation measures for those facilities.

Additionally, PJM incorporates gas pipeline contingency analysis as a part of both our annual assessment of the PJM footprint as well as near real-time assessments undertaken in anticipation of extreme weather. The gas pipeline contingency set includes gas pipeline contingencies caused by the failure of a gas pipeline or loss of a compressor station. The gas pipeline contingency analysis list is reviewed periodically to validate its accuracy.

In addition to the annual studies noted above that are done over the longer planning horizon, PJM completes seasonal operating studies (two per year: summer and winter). These seasonal operating studies assess the PJM system as it is expected to exist during the upcoming peak season. These studies include several sensitivity studies to determine the impact of Maximum Credible Disturbances that are similar to the extreme events noted above that are assessed for the planning horizon pursuant to the NERC Reliability Standard TPL-001-4.

In response to a Federal Energy Regulatory (FERC) and NERC staff report titled *The South Central United States Cold Weather Bulk Electric System Event of January 17, 2018,* NERC and the electricity industry are also developing revisions to reliability standards to enhance the reliability of the bulk electric system during cold weather events. This is a good development and a step in the right direction. Nevertheless, the industry should also consider additional system hardening standards for extreme events going forward.

Importantly, however, while the studies above address the atypical loss of generation, transmission and natural gas pipelines that may result from some extreme weather events, the studies and reliability standards

do not evaluate all scenarios and outages that could result from some extreme weather event. For example, PJM does not currently study all of the facilities that could be impacted by all extreme weather events (e.g., PJM does not currently study all of the facilities that could be impacted by a 500-year flood along the east coast). While conducting such studies would be prudent, there are currently no NERC or FERC requirements or standards that would require reinforcing the system for such extreme events. Therefore, absent more clear resilience standards, a host of objections could be raised by PJM stakeholders that ultimately bear responsibility for paying for such upgrades. Further direction and support from FERC and NERC would be most appropriate to define and set a benchmark for industry planning for resilience of the grid to withstand such extreme events. As noted above, PJM requested such direction and provided a concrete list of over 15 recommendations in response to the Commission's original resilience docket, FERC Docket No. AD18-7-000. PJM intends to raise these issues again at FERC's upcoming technical conference on Climate Change, Extreme Weather, and Electric System Reliability (Docket No. AD21-13-000) to be held on June 21 and 22, 2021.

Question 3: The events in Texas last month illustrate just how intertwined our electric system is with our natural gas production and delivery systems.

a. **What do you view as the benefits or drawbacks of the inter-dependence of the electric and natural gas systems?**

b. **What can we do to enhance coordination and fix existing and future vulnerabilities resulting from this inter-dependence?**

PJM Response: There is no question that the increased deployment of highly efficient natural gas combined cycle generating units in the PJM region underscore the increasing interdependency of the electric system and natural gas production and delivery systems. In our region, natural gas is a highly reliable abundant fuel source. The PJM region also contains an abundance of natural gas storage fields and a rich and diverse set of natural gas pipelines delivering natural gas from the Marcellus and Utica shale gas regions to generation facilities throughout the PJM region. All of these factors have led to a significant increase in development of new highly efficient natural gas combined cycle units.

Of course, with the increased interdependency comes the need for increased coordination. PJM has worked with each of the pipelines serving our region to enhance that coordination. We have established a "gas desk" in our control room facility to monitor pipeline deliveries, particularly during the winter season, and to coordinate operational data with our pipeline partners. We can report a good deal of cooperation among the pipelines serving our region with PJM operators.

Nevertheless, the regulatory paradigms associated with each industry are markedly different. For example, the need for new transmission facilities are determined by an analysis of power flows on the system and whether NERC reliability criteria are satisfied. The costs of such facilities are paid for by the beneficiaries of new transmission lines as determined by an analysis of power flows both before and after the line is operating. By contrast, the need for new pipelines is established not by an assessment of regional need, but instead by contractual expressions of interest by "anchor shippers" which, in some cases, can be affiliates of the pipeline itself. The costs of new pipelines are paid for by these anchor shippers even though the larger

region may benefit from the existence of that pipeline. This difference in how the need for new infrastructure is determined as between gas and electric can create challenges in ensuring that the respective needs of each system are aligned.

The ability of a power generator to vary its demand on the pipeline system in response to changing demand from electric customers can sometimes be limited, especially on cold winter days when the generation owner could be required to purchase gas at the same level throughout a 24-hour period (known as "ratable takes"). These ratable takes help the pipeline to manage pressure but are not well suited for meeting the needs of a generator to rapidly ramp up or ramp down its power input in response to grid conditions.

Finally, although interstate natural gas pipelines are required to serve all customers on a nondiscriminatory basis, whether they are local distribution gas utilities or power generators, local distribution companies – which provide distribution pipeline service to generation owners connected directly to them (known as 'behind-the-city gate') – do not have a similar obligation under state law. This can lead to potential curtailment of power generators needed to serve customers leaving end-use customers with gas supply in their home or business but not necessarily electricity to serve their needs.

Much has been done to increase coordination, but more work is needed. FERC had sponsored a series of gas/electric coordination workshops under then FERC Commissioner Phil Moeller. Consideration should be given to reinstituting those workshops, so the work of each region on these issues can be transparently shared with other regions and the general public.

Moreover, further direction and support from FERC and NERC would be most appropriate to define and set a benchmark for industry planning for resilience of the grid to withstand such extreme events. As stated above, in 2018, PJM requested such direction from FERC and provided a concrete list of over 15 recommendations in response to the Commission's original resilience docket, FERC Docket No. AD18-7-000. PJM intends to raise these issues again at FERC's upcoming technical conference on Climate Change, Extreme Weather, and Electric System Reliability to be held on June 21 and 22, 2021.

Question from Senator James E. Risch

Question: Over the last few weeks, we have seen a number of high profile cyber incidents reported in the news. We know our nation's critical infrastructure is a top target for bad actors and that these threats are persistent, increasing, and growing in sophistication. The Idaho National Lab is not only our nation's lead nuclear laboratory, it is also the go to lab for cybersecurity solutions. What do you see as the biggest cyber challenges facing our nation's energy infrastructure?

PJM Response: Our adversaries are becoming increasingly capable and determined. This is evident in the increase in high-consequence offensives from both nation states and criminal actors. Recent activities have highlighted the capabilities and sophistication of cyberattacks.

The biggest cyber challenges lie in working to stay-ahead of the adversaries. The adversaries are well funded and incented to identify weaknesses in the nation's energy infrastructure. Today, adversaries increasingly focus on attacks to operational technology including supply chain and ransomware attacks. The

adversaries focus on critical infrastructure beyond electricity including gas pipelines, water infrastructure, telecommunications and finance. The industry challenge is to be aware of the interdependencies between all the critical infrastructures. An important acknowledgement is that the adversary will evolve and biggest challenges today will not be the biggest challenges tomorrow.

Threat intelligence and best-practice sharing are critical to managing any cybersecurity program in an evolving threat landscape. We rely on our government partners and vendors to share relevant information that we can use to detect attacks and protect our systems and data. The Electricity Information Sharing and Analysis Center ("E-ISAC") is the hub of information sharing for the electric industry and continues to improve its information sharing programs, making them an essential platform for industry members to share threats with each other. In addition, we receive threat indicators from the Department of Homeland Security and government-informed analysis from the Cyber Risk Information Sharing Program ("CRISP").

As we look forward, the protection of our nation's critical infrastructure must continue to evolve. We must capitalize on the strengths of government and industry partners with clearly defined roles that allow for a powerful force of teamwork. Management of cybersecurity will need to adapt to changes on the electric grid, including the increased focus on distributed technology. Distributed technology introduces a large attack surface for adversaries, and we must plan and prepare for that.

Questions from Senator Maria Cantwell

Question 1: Using Federal Cost-Share Program to Promote Grid Investment

Numerous studies have demonstrated the need and the many benefits of investing in new and upgraded transmission, but the question remains on how to incentivize that investment at the scale and speed we need to meet national decarbonization and grid resilience imperatives.

a. **If the federal government funded a cost-share program to upgrade and expand the national transmission system, do you have any ideas how to design an effective cost-share program?**

PJM Response: PJM's competitive markets, the largest in the world, are enabled by more than 84,200 miles of transmission at 100 kV and above. A robust transmission system lowers the net costs of electricity to consumers by allowing the next most-cost-effective megawatt to be dispatched. This reduces overall production costs for generators and costs for end users of electricity. Transmission lines link PJM zones together, allowing them to share capacity and leverage load diversity to reduce the need for additional generation by up to $3.78 billion annually. (See, e.g., the following PJM white paper on the value of new and existing transmission equipment, lines and other assets for PJM Interconnection stakeholders and other engaged parties: PJM Interconnection, L.L.C, *The Benefits of the PJM Transmission System*, https://www.pjm.com/-/media/library/reports-notices/special-reports/2019/the-benefits-of-the-pjm-transmission-system.pdf (Apr. 16, 2019)).

The transmission system, since its inception, is largely made up of private utilities who develop and construct new transmission and are awarded a return on that investment by the Federal Energy Regulatory

Commission. Notable exceptions exist in the form of Power Marketing Agencies such as BPA, TVA and WAPA and in large public power agencies such as the Los Angeles Department of Water and Power. However, at least in the Eastern Interconnection, public power agencies make up a much smaller part of the overall transmission investment.

At least in the PJM region, the primary issue raised by transmission owners is associated with permitting and siting and litigation over the allocation of the costs of new transmission. However, a federal cost share program could certainly accelerate the build out of the national transmission system and is worthy of consideration.

- **What criteria do you think the federal government should use to decide how to competitively allocate a potentially limited amount of program funds?**

- **Could a cost-share program be based on, or expanded from, the existing DOE Smart Grid Investment Grant program?**

- **What level of federal investment in a cost-share program is needed to make a difference?**

- **Do you know of any existing programs that work well and could be a model for a new federal cost-share program?**

PJM Response: See response to question no. 1 above.

Question 2: Potential Benefits of a National Backbone

Studies have shown that greater interconnectedness of the grid also lowers electricity rates by providing increased access to the least cost sources of generation in addition to making the grid more resilient. At the end of 2019, there was 734 gigawatts of proposed generation — 90 percent of which are new wind, solar, and storage projects —waiting in interconnection queues nationwide.

Despite the significant economic potential, much of it in rural parts of the nation, we are not planning for or building the national high voltage transmission backbone that is needed to take advantage of these incredible energy resources. The challenge seems to be figuring out the most effective way to monetize those benefits and bring a portion of those long-term payoffs forward so they can help pay for the needed upfront capital to make these infrastructure investments.

a. **Would the creation of a national backbone help clear the existing queue of new generation projects waiting to connect to the grid?**

PJM Response: *Defining and Identifying the Benefits and Cautions Associated with a "National Backbone"*: At the outset, PJM suggests clarification around the term "national high-voltage transmission backbone." There already are regional transmission backbones which are characterized by extra-high-voltage transmission facilities, generally at 500 and 765 kV voltage levels. These regional backbones, which are

interconnected within the Eastern, Western and Texas interconnections collectively, represent the grids that provide reliable service throughout the nation.

The larger issue for policymakers is whether there should be a policy-driven directive to build out the grid to meet a public policy objective. Such policy-driven directives could require build-out of transmission to wind-rich areas in advance of specific projects seeking interconnection and/or additional interconnections between regional grids. There are benefits and detriments to such approaches.

Some of the benefits include:

1. Diversification of some of the locational risk from intermittent renewable resource penetration could improve the overall capacity view of renewables as a class;
2. Investment in, policy-driven transmission build-outs, whether intra- or inter-regional could accelerate achievement of decarbonization goals; and
3. Inter-regional transmission links could be very helpful to grid reliability in periods of stress, and can be helpful in providing black-start services.

There are also risks including:

1. To design such a grid to access more renewable generation, one would have to predict where this generation would most efficiently be built in the future. To the extent these predictions were incorrect, some of the buildout cost could be wasted leading to stranded costs borne by customers;
2. Another risk is that shifting the allocation of costs from the generation developer directly to consumers can shift risk and sometimes create incentives to site generation in less efficient places.
3. Siting of transmission is a long, expensive and laborious process and a multi-state siting process will be very time consuming and have a low probability of success. Optimizing existing transmission corridors with advanced transmission line design and high temperature conductors may advance the interconnection of queued generation more quickly.

Overall an investment in "backbone" type transmission can be very helpful in certain cases, but may not be the right solution in all instances. Specifically, any such plan needs to be evaluated in light of several regional factors including pre-existing transmission networks, state and federal policy objectives, resource availability and cost effectiveness. The transparent nature of stakeholder processes within Regional Transmission Organizations provide an appropriate forum for such discussions and analyses.

Interrelationship with the Interconnection Queue: The size of the interconnection queue and backlog issues are affected by several matters. These include the following policies that impact the size and complexity of the interconnection queues and queue process:

- Congressional policy in the form of the wind production tax credit and solar investment tax credit both of which, due to their requirements associated with when construction must commence, drive an increased level of renewable projects to enter the queue all at once in response to the legislative deadlines; and

- The requirements of FERC Order 2003 which require an exact and binding determination of the costs that the interconnecting customer causes through its proposed interconnection so as to shield customers from absorbing any of those costs.

If either a national backbone transmission grid (presumably using a portion of federal funding) were constructed as the question suggests or changes were made to the existing FERC Order 2003 policy, the transmission providers (in most cases the RTOs and ISOs across America) would be able to focus the interconnection queue process on the electrical and physical requirements of interconnecting new facilities without having to also determine, through complex studies, the exact "but for costs of each new interconnection. This would help to speed the interconnection queue process but, on the other hand, could be seen by customers as shifting to them costs which otherwise should be borne by developers who will benefit from that interconnection. These policy questions are worthy of further examination and deliberation by the FERC and by this Committee.

b. If the U.S. had a national backbone in place, would that have potentially helped avoid or mitigate the power crisis in Texas last month or California last August?

PJM Response: Based on the preliminary information available to date, while more transmission may have helped, it is not clear it would have avoided the crises. While transmission is sometimes the best solution to ensuring the reliability of the bulk power system, at other times generation investment, demand response, or energy efficiency investment is needed. As a result, we need to be careful to invest in the right mix of all these solutions to deliver reliability as efficiently as possible.

Within the Eastern Interconnection, the ties between utilities are quite strong as is a long history of mutual support. For instance at the height of the cold weather spell in the Midwest earlier this year, PJM was exporting as much as 15,700 MW, a record, to our neighbors to assist them in meeting their load requirements. The strong transmission grid in the Eastern Interconnection made those transfers possible.

c. Will private sector markets build a national backbone or should the federal government, through the existing Power Marketing Administrations or another federal entity, build and operate such a system?

PJM Response: As noted in response to Question #1, at least in our region, the impediments to additional transmission are largely driven by permitting and siting challenges and litigation over who pays for such transmission projects. Were there to be an intense focus on these issues among applicable federal and state regulators, the private sector, interested in earning a return on new transmission investment, would most likely be willing to fund the necessary transmission build-out. Moreover, the private sector is more likely to respond to market-based incentives.

Question 3: Infrastructure Right-of-Ways

The past year has demonstrated that reliable electricity and broadband access are essential to modern life. Both these services rely on rights-of-way to bring services to American households and businesses.

a. Do you support the concept of pairing new transmission and high-speed internet infrastructure into the existing right-of-ways?

PJM Response: PJM is not directly involved in determining the best location to site new transmission facilities. However, the use of existing right of way and the pairing of new transmission and high-speed internet infrastructure has proven a very viable means to site needed new infrastructure. Particularly in a densely populated region such as the PJM region, new greenfield right of way can be difficult to find and can carry with it many environmental challenges. It is for this reason that we have seen a number of "wreck and rebuild" projects which enhance transmission capability using existing rights of way.

b. How could surface transportation right-of-ways be used to build out additional electricity transmission capacity? Do you see this opportunity linked with future demand for EV charging?

PJM Response: Although PJM is not directly involved in determining the best location to site new transmission facilities, we have seen the increased siting of new transmission lines along public highways and rail lines. Moreover, should there be concentrations of demand for EV charging, say along a national highway, "Park and Ride" lot, step-down facilities could be created to service EV charging. The economics of any such application would need to be addressed on a case by case basis. Nevertheless, system planners at both the transmission and distribution levels will need to give increased attention to ensuring adequate infrastructure that supports customer-convenient EV charging stations in their planning and siting decisions.

c. Do you think a federal "Dig Once" policy could facilitate the use of existing right-of-ways to build new transmission capacity?

PJM Response: PJM does not have field crews nor are we directly involved in the construction or maintenance of physical facilities. Rather those tasks rest with the transmission and distribution utilities within our region.

Transmission facilities today largely consist of overhead wires anchored to towers in the ground. By contrast, laying of cable for a fiber optic network can involve an entirely different and more extensive level of excavation through a dedicated trench. There have been instances where fiber optic cable for communications is co-located on transmission towers. In these latter instances, a flexible federal policy may help to ensure coordinated development of both communications and electric transmission infrastructure in a manner that meets the needs of the public which ultimately demands timely provision of both services. On the other hand, each individual situation is different and strict application of a "Dig Once" policy may inhibit timely development and installation of needed transmission or communications technology. As a result, this area may not lend itself to an across-the-board legislative solution.

Questions from Senator Lisa Murkowski

Question 1: Your testimony states that PJM has a robust reserve margin. Can you discuss PJM's planning reserve margins and what your company is doing to go beyond NERC's Reference Reserve Margin?

PJM Response: The PJM installed reserve margin target represents the level of reserves PJM needs to procure over and above the forecast of peak demand for electricity in a given year. The installed reserve margin is set by PJM using established tools to forecast the demand for electricity at peak periods in the summer and winter and also takes into account the potential loss of generation due to forced outages as

well as the level of support available from our neighbors. Based on this analysis and input from stakeholders, PJM establishes the installed reserve margin target on an annual basis.

PJM has designed its procurement of capacity so as to recognize the value to reliability and to customers of procuring additional resources over and above the installed reserve margin target. Specifically, PJM utilizes a sloped demand curve that recognizes when there is additional generation available. The rationale for the sloped demand curve is anchored in the fact that it is in the interest of customers to procure additional reserves at an overall declining price. In effect, by use of the sloped demand curve in PJM's procurement of capacity, the customer realizes the benefits of additional reliability to respond to stresses on the system such as loss of generating units, at a declining overall price per megawatt of capacity procured.

As noted in Mr. Asthana's testimony, PJM is willing to work with customers and stakeholders to further analyze whether additional enhancements need to be made to the determination of needed reserve levels to reflect the potential stresses on the system resulting from a correlation of extreme events such as cold temperatures and losses of generating units due to flooding and icing occurring over multiple days. There is no one clear way either to model these events or to find the proper balance between, on one hand ensuring adequate reserves during extended extreme weather events vs. on the other hand, ensuring that the cost of electricity remain reasonable and affordable to the citizens and businesses in our 13-state footprint. PJM intends to work with its stakeholders on these complex matters in this area so as to further improve the reliability of electricity supply and delivery to the 65 million Americans we serve.

Question 2: According to the Energy Information Administration, natural gas accounted for almost 40 percent of generation capacity last year. There is broad recognition that conventional power generating resources will continue to play an important part in providing affordable and reliable electricity if winterized. Will conventional sources of baseload power generation - like natural gas, coal, and petroleum - remain a part of PJM's energy mix even as the U.S. pursues cleaner sources of power generation?

PJM Response: The PJM region will continue to need supporting dispatchable generation to make up for the intermittent nature of renewable generation. Today, that generation will come from fossil resources although in the future new technology such as enhanced duration batteries may begin to displace some of those fossil resources. The fossil generation that will be needed to support the grid cannot be characterized in the future as "baseload generation." In fact, it may only be called to operate more like a peaking plant today than a more traditional coal fired or nuclear generator.

In the future, there will be an increased need for generating plants that are able to quickly ramp up and down and otherwise have flexibility to meet the variable nature of solar and wind output.

Question 3: Similar to Texas, but for different reasons, Alaska is not connected to the national grid. Instead, we rely on our Railbelt grid and the 200 microgrids, which are built to withstand the harsh winters and surprisingly hot summers. Microgrids have transformed energy systems in rural Alaska communities, allowing them to maintain reliable power generation using diesel fuel while incorporating locally available resources like hydro or wind to reduce energy costs and emissions. Are microgrids cost-effective assets to

improve the reliability of the national grid, and could you speak to the PJM's work in this space, particularly the Microgrid Center of Excellence?

PJM Response: In a state like Alaska, microgrids may well be more efficient for remote communities. With regard to the transmission system within PJM that is serving significantly more densely populated areas, the bulk power system still provides benefits over microgrids; however, microgrids within the bulk power system can be an excellent combination for those customers who want or need extraordinary reliability or resilience.

Microgrids offer increased reliability and resilience within the bulk power system. A standalone microgrid outside of a larger grid system can be costly. Microgrids tend to be more cost effective for customers and communities that are already connected to a larger grid system only when they have a need for extraordinary reliability and resilience standards (e.g., hospitals, labs, critical infrastructure) or where there is some other social or local driver (e.g., New Jersey post Hurricane Sandy). The scale and interconnectedness of power grids still brings tremendous value and reliability to millions of Americans.

Often times, the economic value proposition for microgrids is dependent upon those resources within the microgrid also providing wholesale services to PJM or other competitive markets. The formation of a microgrid is typically made up of distributed energy resources and with the recent FERC Order 2222, efforts are under way to further offer wholesale participation opportunities for distributed energy resources that also operate as part of a microgrid. The potential proliferation of distributed energy resources may translate to more microgrids within the PJM grid.

The wholesale power market offers both revenue and cost saving opportunities through the use of microgrids. Examples of the use of microgrids to generate revenue or reduce electric power costs and investment expenditures in PJM include the Borough of Berlin, PA, which runs its microgrid up to 100 hours annually to reduce coincident peak charges, the Philadelphia Navy Yard (Microgrid Center of Excellence), and Princeton University.

Recently, PJM and its stakeholders have been working to ensure that resources within a microgrid have adequate access to wholesale markets and that their operation, when islanded from the bulk power system, is visible to grid operators.

Question 4: A focus of this Committee has been keeping pace with evolving threats to our nation's energy security, which includes cyber and physical threats. I was discouraged to see President Biden suspend the Executive Order on Securing U.S. Bulk-Power Systems because we can't forget to protect the grid from foreign adversaries as we work to strengthen the grid against climate change. PJM purchases electrical equipment from around the world. How do you protect your supply chain?

PJM Response: PJM's supply chain cybersecurity focuses on hardware, software and services that we utilize to serve our mission. PJM does not own the electrical equipment or administrate procurement of electrical equipment and that is a function of the transmission and generation owners.

The current version of the NERC Cybersecurity Supply Chain Risk Management standard has been effective as of Oct. 1, 2020. This standard provides an excellent starting point for advancing controls to

mitigate the risks associated with threats and vulnerabilities in the supply chain. Supply chain standards and best practices need to evolve continually. The breadth and depth of the supply chain creates unique and significant challenges. Coordinated and prioritized actions between industry and government are critical success factors. Reliable and secure supply chain management will require broad cross-sector engagement, broad government engagement and a significant shift in how vendors and service providers deliver products and services to substantially mitigate supply chain risks.

There is a role for our government partners to provide clear direction about vendors who put national security at risk. Additionally, the DOE and other government partners are in a position to develop testing and certification programs and will need to find the balance between government programs and competitive third-party programs.

Question 5: During the recent cold snap and whenever we have a prolonged blackout, we are reminded of just how critical it is that power continue to flow. We know that a catastrophic failure of electric service is simply unacceptable in today's world.

In light of the experience that many recently suffered with a loss of power for only about three days, and considering the potential for a loss of electricity over many states such as we saw in 2003, and taking into account what we have learned about the threat of major cyber-attack and other "low frequency/high impact" events on today's interconnected electric grids that could produce a loss of electricity for a much longer duration over wider areas --

a. **What is the plan for assuring the grids covered by the regional reliability entities that report to NERC and the broader interconnections are protected against a major cyber-attack?**

PJM Response: Ensuring grid protection against a major cyberattack is a collaborative effort between industry and government partners. Partnership and collaboration are essential to any cybersecurity or physical security program. The importance of working across the industry, and with our state and federal government partners – and even across other critical infrastructures like telecom, finance, water and gas – to share threat information and best practices cannot be overstated. Threat intelligence and learning from others in relation to threats and prevention is critical to managing any cybersecurity program.

PJM and the electricity industry have a good start through industry compliance efforts, which focus on best practices. The CIP standards provide a strong baseline for protecting and defending our critical assets. Incident response for cyber and physical events has been a high priority of the electricity subsector and has resulted in a number of vital efforts that have prepared us for coordinated response to high-consequence events.

The industry principally utilizes the Cybersecurity Framework, developed by the National Institute of Standards and Technology, as an approach to managing cybersecurity. The framework focuses on the principal functions to identify, protect, detect, respond and recover. Cybersecurity best practices begin with protecting our assets, detecting bad actors, responding to events and recovering from events. Establishing key performance indicators (KPI) and metrics for each of the principal functions is essential. You cannot

control the reconnaissance that an adversary is doing, but you can control the layers of defense and the action you take to avoid or mitigate a breach.

One of the most important programs that the electricity industry has engaged in is the NERC GridEx program. This program exercises extreme events occurring across multiple electricity utilities, and includes both cyber and physical injects. It exercises coordination between utilities, the E-ISAC, and participating state and federal government entities. Lessons learned from these exercises improve the ability of utilities and government entities to work through unforeseen future events by having ready plans that have been tested through hypothetical, extreme scenarios. PJM also performs drills with the members in our footprint, building off the NERC GridEx experiences. Incident response is critical and requires preparation and practice. Moreover, as noted above, PJM receives threat indicators from the Department of Homeland Security and government-informed analysis from CRISP, which is a program that facilitates the timely sharing of cyber threat information and develops situational awareness tools to better protect against and respond to cybersecurity threats. CRISP is an excellent public private partnership that leverages the expertise of PNNL to provide enhanced situational awareness to aid in determination of depth and breadth of malicious activity.

b. Insofar as the military doctrines of nation-states such as Russia, China, North Korea and Iran includes nuclear electromagnetic pulse (EMP) as extensive cyber threat, what is the electric sector's plan, at the utility, reliability regional entity, and national level to assure the grids are protected against that threat?

PJM Response: The electric sector is actively working on addressing the risk posed by EMP. PJM has collaborated, and continues to do so, with NERC, EPRI, and DOE to assess the susceptibility of the grid to EMP. PJM Manual 13 (*Emergency Operations*) contains procedures for EMP events as well.

In 2015, EPRI initiated a 3-year project to study the impacts of EMP. The research included both large-scale power system simulations and hardware testing. In 2019, NERC launched the EMP Task Force to share best practices and develop reliability guidelines. In 2020, DOE released an unclassified HEMP waveform that can be used as a benchmark in power system studies.

Some utilities, when appropriate, have also included EMP specifications in their facilities.

c. Insofar as a natural event such as a geomagnetic disruption (GMD) is statistically likely to occur at some point, how are you working (and with whom) to plan for and assure that the grids are protected against and able to recover from that threat?

PJM Response: PJM's plans in this area are supported by two key NERC reliability standards: Geomagnetic Disturbance Operations (EOP-010), and Transmission System Planned Performance for Geomagnetic Disturbance Events (TPL-007).

These two standards impose a compliance obligation on the electric grid owners and operators to mitigate the risks associated with a 1-in-100 year GMD event. To put that in perspective, the 1989 geomagnetic event that resulted in the Quebec blackout lies around 1-in-50 year event. As another point of reference, you could compare the GMD standard to other terrestrial weather design basis – in general, wind loading, icing, and

other conditions are designed around 1-in-50 year events. NERC's GMD standard has one of the most stringent requirements with respect to the return period.

PJM's GMD mitigation strategy is based on three pillars: (1) Equipment Hardening, (2) Situational Awareness, and (3) Operational Procedures.

PJM has worked closely with our TOs and GOs to engineer solutions using each of these pillars. Utilities have taken multiple actions to harden the grid – for example, enhancing of protection system, modifying transformer specifications, etc.

PJM also collaborates with NASA and NOAA to improve GMD forecast capabilities. PJM's operators receive NOAA's early warnings (typically more than 14 hours ahead) and can position the system to withstand the impacts of GMD in these instances. Situational awareness is enhanced with real-time geo-magnetically induced currents (GIC) measurements from the field. In the case of a severe storm, PJM's operators would declare conservative operations and follow operating procedures described in PJM's Manual 13, section 3.8, which outlines PJM's GMD Operating Plan and sets forth our emergency procedures for preparing for and operating through these type of events.

Attachment 1

Executive Summary from PJM Comments Filed in

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

Document Accession #: 20180309-5192 Filed Date: 03/09/2018

UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

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

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

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

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 System[2] ("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

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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 management[5] 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 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.[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.

III. COMMENTS

As the Commission indicated, at the most basic level, ensuring resilience requires determining which risks to the BES to protect against, and identifying the steps that are needed to ensure those risks are addressed.[11] The Grid Resilience Order, *inter alia*, asks three broad questions. First, how should resilience be defined?[12] Second, how do RTOs assess threats to resilience?[13] Third, how do RTOs mitigate threats to resilience?[14] PJM's responses to the

[9] One possible manner of imposing obligations on LDCs might be as customers of interstate pipeline tariffs.

[10] PJM is focusing efforts on the second tier of generation used in restoration, commonly referred to as critical load units, and referred to herein as Critical Restoration Units.

[11] Grid Resilience Order at P 24.

[12] *Id.* at P 23.

[13] *Id.* at P 25.

[14] *Id.* at P 27.