



U.S. Senate Committee on Energy & Natural Resources

Testimony of Manu Asthana

President and CEO, PJM Interconnection

March 11, 2021

For Public Use

This page is intentionally left blank.

Contents

Introduction	1
Executive Summary	2
Reliability: Job #1.....	3
<i>Stress Testing: A Key Component of Reliable Operations</i>	4
<i>Addressing Extreme Weather Conditions</i>	5
Resilience: Beyond Reliability	6
<i>Learning from Extreme Events</i>	7
PJM Markets Reinforce Reliability & Support Affordability	7
<i>Available & Affordable Electricity</i>	9
The Energy Transition	9
In Conclusion	12

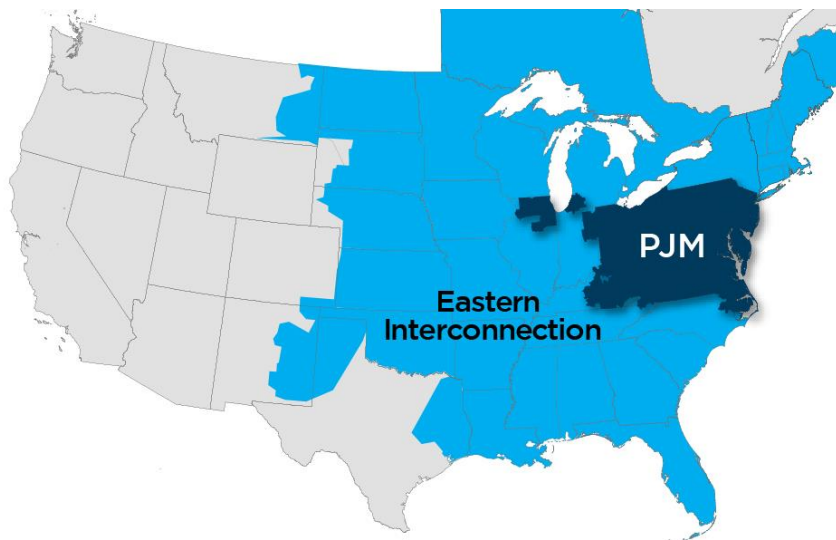
Introduction

I am Manu Asthana, president and CEO of PJM Interconnection. On behalf of PJM, it is a pleasure to participate in this hearing and share PJM's perspective on the reliability, resilience and affordability of the bulk power grid.

Based in Valley Forge, Pennsylvania, PJM Interconnection ensures the reliable flow of power to 65 million customers in 13 states and Washington, D.C. As such, we're responsible for ensuring reliable and efficient delivery of electricity over the bulk electric system to one-fifth of the nation.

The PJM grid consists of 85,103 miles of transmission lines and approximately 1,200 generation sources, along with more than 500 demand response and energy efficiency providers. We are interconnected with our neighboring systems in the Eastern Interconnection, which geographically includes over two-thirds of the United States and Canada. PJM delivers power from the high-voltage transmission grid to local distribution utilities, who then are responsible for delivery to end-use customers.

Figure 1. PJM Service Territory



Our markets exist to reinforce grid reliability by ensuring that, in addition to our reliability requirements on generators, market signals work in tandem with those requirements to support reliable operations. For example, our capacity market is designed to procure resources available to meet projected peak demand and other contingencies three years ahead of time. Through our Day-Ahead and Real-Time markets, we produce a security-constrained economic dispatch across our footprint, ensuring that the most efficient and cost-effective mix of resources are called on each hour of each day to achieve reliability at the least cost to customers. In addition, in any given hour we either export excess power supplies to our neighbors or import needed power from those neighbors, which helps support reliable and cost-effective operations throughout the Eastern Interconnection.

Executive Summary

My testimony addresses the three key foundations which are the subject of this hearing – reliability, resilience and affordability. Relative to these three guiding principles, a few key points are central:

- Reliability and security of the bulk-power grid is our first priority and our organization's driving purpose.
- Our grid is strong, with a set of diverse generation resources, healthy reserves, a robust transmission system that is interconnected with our neighbors, and a transparent planning process – each of which helps maintain reliability in adverse conditions. Nevertheless, ensuring the continued strength and reliability of the grid requires our constant attention. We meet this challenge with the strong and helpful support of our transmission and generation owners, our states, our large and diverse stakeholder community, and industry partners such as the natural gas pipeline companies that support gas-fired generators in our footprint. The Federal Energy Regulatory Commission (FERC) and the North American Electric Reliability Corporation (NERC) are important overseers in this effort.
- PJM prepares for threats to the bulk power system by stress testing the system and analyzing literally millions of possible contingencies. This contingency analysis includes analysis of planned as well as unplanned transmission and generation outages, impacts of extreme weather, fuel shortages and other scenarios. Additionally, because it is impossible to foresee every possible contingency, PJM and its members expend considerable effort preparing to recover from unforeseen disturbances on the grid.
- PJM's markets exist to deliver reliability at the lowest cost over time. Our capacity market is designed to procure adequate resources, three years forward, to be available to cover projected peak demand as well as a reserve for contingencies. Our energy and ancillary services markets perform a security-constrained unit commitment and dispatch to ensure selection of the lowest-cost resource mix to serve customers while respecting the physical limits of the grid.
- In addition to reliability, affordable electric service has been one of the bedrock principles since the early development of electricity to light our homes and businesses. Our markets, in combination with our operations and planning functions, are estimated to deliver \$3.2 billion to \$4 billion in annual efficiencies for customers. As we prepare for the grid of the future, we need to continue to ensure that affordability remains a key component of our collective thinking.
- The transition to a more decarbonized grid has been underway in PJM for the last 15 years, and this now appears to be accelerating as a result of policy choices by a number of our states, technology advances and evolving consumer preferences.
- As we see significant growth in intermittent renewable generation on the grid, ensuring continued reliability will remain our top priority. This will require deliberate and thoughtful effort and partnership among multiple parties, including PJM, our states, our transmission and generation owners and other stakeholders, and regulators such as FERC and NERC. Along with our stakeholders, we are adopting a more precise method to calculate the capacity value of intermittent resources during periods of peak demand. Going forward, we will need to consider new reliability products and services to ensure adequate availability of dispatchable supply resources at all times.

- By the same token, improvements to load and renewable generation forecasting, the setting of reserve margin targets (including consideration of the potential for extreme weather events), as well as enhancing the visibility and dispatchability of distributed energy resources, will all need further development going forward. Thoughtful approaches and carefully synchronized timing of all of these efforts will be needed, both at the PJM stakeholder level and at FERC, to ensure this transition is successful.
- As we have seen in many past situations, events such as extreme temperatures do not always occur as simple stand-alone events. Rather, there is often a correlation of events, such as extremely cold temperatures coupled with ice storms or the potential for multiple cybersecurity intrusions for which we need to plan. PJM is committed to learning from extreme grid events, whether they happen in our region or elsewhere. We will evaluate the analyses of the recent events in Texas in light of lessons learned from our own past experiences. Some key questions we are considering include:
 - *While most generation on our system has prepared for cold weather, should additional FERC policies, NERC standards and PJM rules be established to focus on winterization of resources, and to address additional areas of resilience of both the grid and generating units?*
 - *Should enhanced “circuit breakers” be established in power and gas markets to protect consumers from extreme prices during periods of extended scarcity, market dysfunction or compromised system operation?*
 - *What further coordination with transmission and distribution providers, fuel suppliers and generation owners is warranted to lower the risk that supply of fuel and other critical inputs to the production of electricity is disrupted during stress conditions?*

Answering these questions will require coordination among PJM, FERC, NERC, the gas industry, states and stakeholders.

- PJM believes that our markets should be designed to accommodate state policies related to the generation resource mix, while also ensuring that we have the products (and adequate compensation to providers) in place, in a timely manner, to meet the reliability needs of the system going forward. We are presently involved in a series of workshops with our stakeholders on these very issues, and it will take continued federal leadership, coordination with our members, states and other stakeholders to accomplish this goal.

Reliability: Job #1

At PJM, reliability is our top priority. We understand the profound implications of what we do and how important electricity is to daily life. We understand that we must prove ourselves every day by ensuring the reliable delivery of electricity that is so central to the economy and health and well-being of the 65 million Americans in our footprint.¹

PJM has been ensuring reliability at the bulk power level to our region going back to 1927, when three utilities recognized the synergies of sharing power and created the first continuous power pool.

¹ I am attaching to this testimony the white paper “Reliability in PJM: Today and Tomorrow,” which provides additional explanation of how PJM addresses reliability through our markets, planning and operations functions.

That value proposition endures today: Both in regions with regional transmission organizations (RTOs) and those without RTOs, the industry has a long history of mutual support. However, PJM's regional approach, operating across a very large footprint with many more resources and tools available, ensures a stronger grid than might exist if every utility in our system had to ensure reliability solely on their own. PJM's rigorous planning process ensures a reliably planned system for the long term over a wide range of operating conditions.

Reliable operation is complex, involving multiple layers of protection. It involves 24/7 system monitoring and dispatch by trained operators, coordination with other operating entities and industry sectors in real time, markets that support reliability and resource adequacy over the long term, and extensive regional transmission planning to ensure the grid is equipped to serve future needs.

Stress Testing: A Key Component of Reliable Operations

Testing for different scenarios and stress testing the system is an integral part of both daily operations and our long-term planning. By way of example, we analyze changes to the expected load forecast due to weather conditions, the effect of the pandemic, and other near-term events, including:

- Maintenance outages of transmission and generating facilities
- Impact of sudden unplanned outages of generation or transmission
- Forecasted adverse weather conditions across the footprint
- Fuel-related contingencies such as loss of pressure or supply on natural gas pipelines that serve PJM
- System stability including the impact of periods of low wind availability

In addition, through our open and transparent transmission planning process, we are analyzing the need for upgrades and new transmission build-outs through a five, eight and 15-year-forward, multi-scenario analysis, which includes:

- Producing a load forecast that accounts for multiple scenarios including factors such as changing weather patterns, different levels of economic growth, and customer-driven energy efficiency and demand response actions that impact electricity demand
- Examining fuel security by analyzing 324 winter scenarios in which we varied factors such as the generation fuel mix, winter weather severity and duration, level of gas availability, oil refueling capability, system-wide forced outage levels, and the number, severity and duration of pipeline disruptions
- Developing an annual Installed Reserve Margin (14.7 percent in 2021) to ensure the availability of sufficient generation resources during stressed system conditions
- Ensuring the stability of the system both under normal and adverse conditions
- Complying with NERC and local reliability criteria
- Finding opportunities to use transmission to lower customer costs through market efficiency projects

- Working with transmission owners on plans to mitigate or eliminate the risk of cyber or physical damage to our most critical facilities through build-outs and upgrades that go above and beyond what is required today under NERC standards
- Providing our states with the tools to develop transmission projects that meet particular state policy goals

In both real-time and day-ahead operations, we are able to utilize a host of tools, rooted in both market signals and longer-range transmission planning, to keep the system operating reliably and resiliently to meet not just normal operating conditions, but when it is necessary to “expect the unexpected.”

Addressing Extreme Weather Conditions

I wish to address the issue of preparation for temperature extremes, both from the point of view of PJM operations and, in the separate section below, from the point of view of how PJM’s market design reinforces reliable operations.

Although I am not here to say that we couldn’t face challenges during extreme weather conditions (indeed, no one can), PJM has a large, multi-state geographic footprint, a diverse fuel mix, a robust reserve margin and strong interconnections with our neighboring systems, all of which help keep the power flowing. Most generating resources in our footprint are built with freezing temperatures in mind, and our members prepare and winterize, in part, because of the nature of the region, which covers much of the Atlantic seaboard and upper Midwest.

PJM and its member companies plan throughout the year for winter – and summer – conditions. We have incorporated into our manuals an extensive pre-winter preparation checklist. This checklist, directed to generators, covers a variety of winterization actions to be undertaken. Generators report the results of their analysis to us through our electronic e-DART reporting system. Even though the reporting is voluntary today, we have received a high level of generator compliance, particularly from those units that otherwise could face the most weather-related impacts. In addition, at the start of the summer and winter season, we conduct emergency response drills with our members and natural gas pipeline operators, and survey generators regarding their fuel inventory.

PJM and members’ preparation includes everything from increasing staffing for weather emergencies, if needed, to coordinating maintenance activities that ensure equipment is ready for winter conditions. The extensive preparations of our members, and the close coordination with those members and other stakeholders, support PJM’s readiness to address unforeseen outages or other system disruptions. All these elements have contributed to a definite trend of improved performance of our generation resources.

We saw this during the severe weather in mid-February of this year that impacted much of the country. Although the weather was not as cold in most of our region (although we did see extremely cold temperatures in the western portion of our region around Chicago), PJM generators demonstrated high availability to operate reliably under winter conditions. That, combined with a strong transmission system, enabled us to export as much as 15,700 MW of electricity – a record amount – to support our neighbors who were experiencing extreme weather conditions. This was more than three times the megawatts we would export on an average day.



The entire Eastern Interconnection, although stressed in the southwest, was certainly stronger as a result of this massive level of exports and support by PJM to neighboring systems. And, as noted previously, our neighbors have provided us support at times when the shoe was on the other foot, and system conditions in PJM could be alleviated with imports from our neighbors.

Resilience: Beyond Reliability

As we have said, the system is sound today. PJM's transmission system consists of a robust 500 kV and 765 kV "backbone" that has withstood extreme weather conditions and has continued to perform well. However, the grid needs constant attention. Part of that task requires policymakers, transmission owners and grid operators like PJM to address the need for specific improvements to ensure that the grid is not just reliable, but also is resilient going forward, to withstand some of the extreme conditions we could well be experiencing in the future.

The distinction between resilience and reliability has been extensively debated in a now-closed docket before FERC. PJM defines resilience as: "preparing for, operating through, and recovering from events that impose operational risk, including but not limited to, high-impact, low-frequency events that today are not typically addressed by industry reliability standards."

Perhaps as a prime example: We are in the middle of a high-impact, and hopefully low-frequency, event in the form of the COVID-19 pandemic. And while PJM has had a pandemic response plan in place since 2006, this event has demonstrated how we need to "expect the unexpected" and ensure that the system is resilient to withstand those unexpected events.

PJM has responded to this challenge by staying focused on building resilience to the impacts of the pandemic into our operations, remaining flexible and learning as we go. We have successfully run our operations, planning and markets with 90 percent of our workforce working remotely. Operators on campus are now in their second round of sequestration to ensure continued operation of the grid. We improvised a third control room as a backup to our two existing control rooms, which normally support each other. And we have managed to conduct about 400 meetings with our stakeholders, all remotely.

Another example of PJM preparing for a resilient grid can be seen through detailed work we performed on:

- Impacts of future generation unit retirements and changing fuel mix²
- Analysis of the security of fuel supplies and fuel delivery mechanisms in PJM³
- Potential security disruptions to the natural gas pipeline system and its impact on PJM generation

PJM and its stakeholders continue to add extreme scenarios for consideration in our operations and planning processes.

² [PJM's Evolving Resource Mix and System Reliability](#), March 30, 2017

³ [Fuel Security Analysis: A PJM Resilience Initiative](#), Dec. 17, 2018

Learning from Extreme Events

PJM is committed to learning from extreme grid events, whether these occur in our region or elsewhere, and to using these lessons learned to improve the reliability and resilience of our system. Some examples include:

- Review of Southwest 2011 Winter Event: PJM established winterization steps to be taken by generation unit owners and established a reporting system to PJM, as well as provisions to secure additional reserves to address both winter and summer stressed conditions.
- 2014 Polar Vortex Event: PJM made changes to its capacity market design to provide significant penalties for poor generator performance and payments for superior generating performance during identified stress conditions.
- Gas/Electric Coordination: PJM established protocols with natural gas pipelines serving our region to ensure real-time communication and contingency analysis during times of stressed conditions on the interstate pipeline system.
- 2021 Cold Weather Grid Operations: PJM is carefully monitoring the information coming out of the various reviews in ERCOT and will evaluate lessons learned from that analysis, with an eye toward examining what is applicable to our region. However, I believe at least three important questions arise for broader consideration by PJM, our members and our regulators, given what we know so far:
 - 1) *While most generation on our system has prepared for cold weather, should additional FERC policies, NERC standards and PJM rules be established to focus on winterization of resources and to address additional areas of resilience of both the grid and generating units?*
 - 2) *Should enhanced “circuit breakers” be established in power and gas markets to protect consumers from extreme prices during periods of extended scarcity, market dysfunction or compromised system operation?*
 - 3) *What further coordination with transmission and distribution providers, fuel suppliers and generation owners is warranted to lower the risk that supply of fuel and other critical inputs to the production of electricity is disrupted during stress conditions?*

Answering these questions will require sound coordination among PJM, generation, transmission and distribution owners, FERC, NERC, the gas industry, states and other stakeholders.

PJM Markets Reinforce Reliability & Support Affordability

As I stated earlier, the markets PJM administers serve to reinforce reliable grid operation efficiently. The markets have also opened the door to new, innovative products such as Energy Efficiency and Demand Response, which function to reduce electricity demand and save customers money.

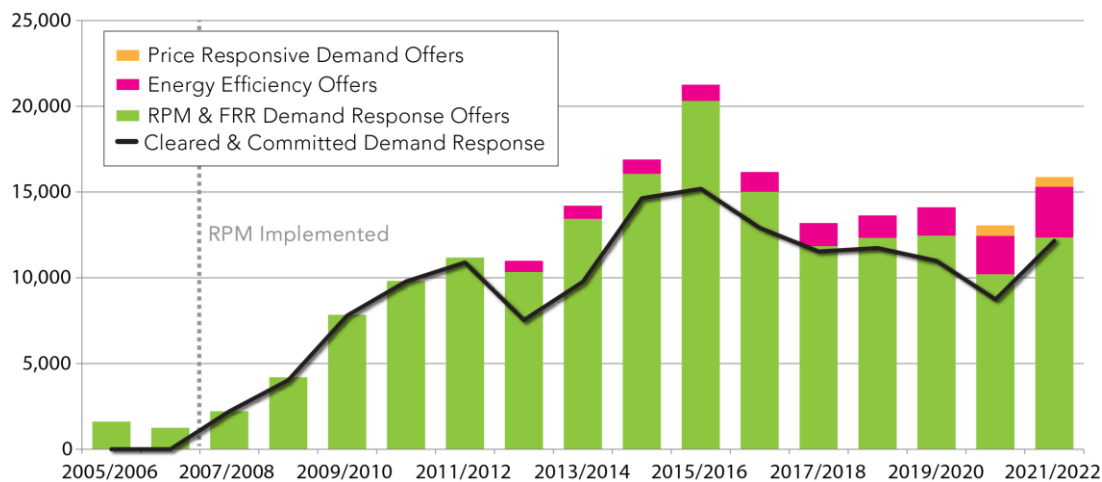
Even fully regulated states benefit from the organized wholesale markets. Utilities located in those states can buy and sell electricity in the markets when they need to, or when it makes economic sense. Regulated utilities and states also benefit from the transparency of wholesale market prices – using them as a comparison when making electricity supply investment decisions.

The PJM market design integrates reliability with affordability by selecting the lowest-cost power source, wherever it is located, to provide electricity to wherever it is needed, subject to physical network transfer limits over a wide region. Our primary markets are the energy and capacity markets. Each market serves a separate function, but they work in tandem.

I will describe the capacity market first, because although it represents about 20 percent of our total market, it is squarely aimed at maintaining reliability. PJM's capacity market was implemented to secure enough power supplies at locations they are needed to make sure that sufficient supply is available to meet peak demand three years into the future, taking into account anticipated outages of individual resources and required reserves for other contingencies. Under a normal schedule, we hold a three-year-forward auction in May. That is extremely valuable from a reliability perspective.

The capacity market also helps provide an investment signal to attract new efficient generation and to retire older, less efficient generation. It can help to avoid some of the volatility we would otherwise see in an energy-only market. The design of the capacity market also results in the purchase of resources beyond the minimum reliability requirement, providing additional reliability for unforeseen events, with each megawatt of reliable supplies beyond the minimum being procured at a declining cost to the customer. Moreover, as noted below, the capacity market has encouraged innovation and led to the penetration of Energy Efficiency and Demand Response as market products that can be called upon to cut demand in times of stress, further bolstering reliability.

Figure 2. Increasing Demand Resources in the Capacity Market



As a result of extreme weather conditions our region realized during the Polar Vortex of 2014, we made notable changes to our market design to ensure that the market both rewards superior generator unit performance and penalizes poor generator unit performance. During the 2014 Polar Vortex, up to 22 percent of generators in our footprint were unavailable as a result of forced outages.

As a result of the winterization procedures, which I described above, along with the incentive and penalty reforms we instituted in 2016, we have seen a notable improvement in generator performance including during periods of extreme weather. Forced outages during the recent cold weather in the PJM region peaked at 9.8 percent during the coldest weather of Feb. 15-17, compared with the 22 percent during the 2014 Polar Vortex, as noted above.

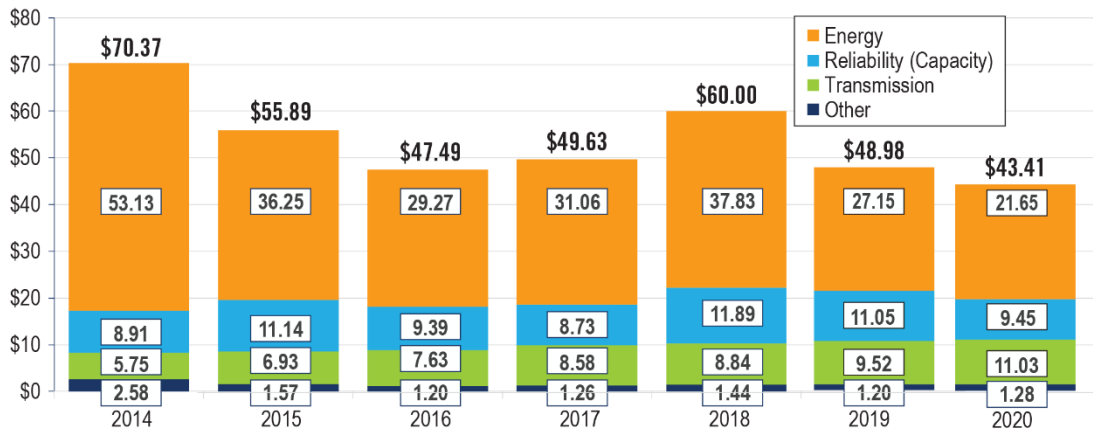
Nevertheless, we are not resting on these past achievements but looking forward to ensure that grid reliability is maintained under a paradigm of more extreme weather and a changing generation portfolio. I address this further in The Energy Transition section on page 10.

The largest of the PJM markets is the Energy Market, making up the majority of wholesale electricity costs. While the capacity market prepares for the future, the Energy Market addresses near-term need. Energy prices are produced on average every five minutes, as the most cost-effective resources across the PJM region are dispatched to serve ever-changing demand.

Available & Affordable Electricity

In aggregate, our markets have helped support an overall decline in total wholesale costs in recent years. Total wholesale prices were \$43.41 in 2020, down 38 percent from 2014. PJM’s wholesale prices have been essentially flat for two decades and are competitive with other regions of the country. The Energy Market, which is about 60 percent of the PJM markets, saw historic low prices in 2020.

Figure 3. Total Wholesale Cost (2014-2021)

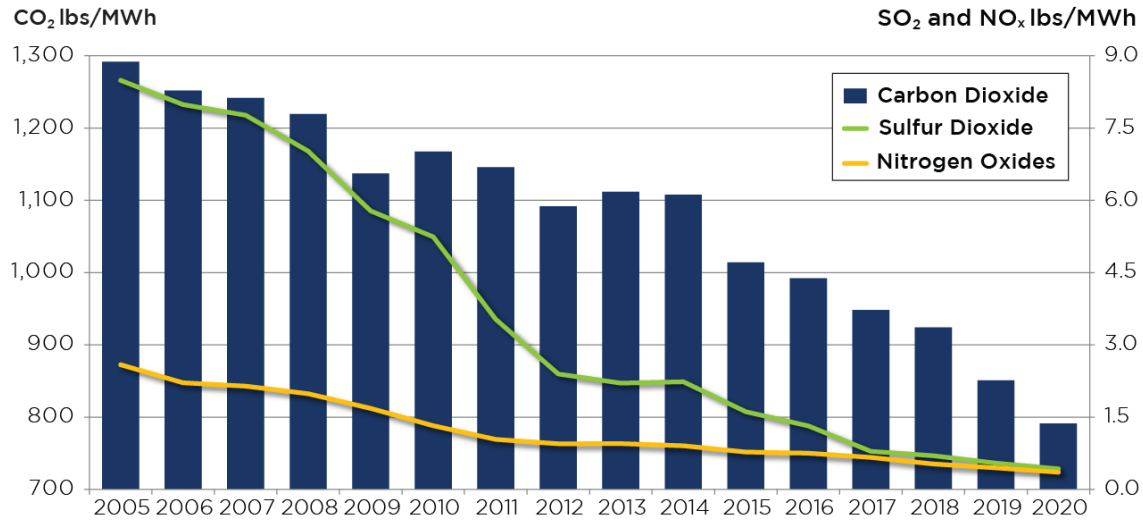


I should also note that wholesale costs are just one component of the overall customer bill. Customer bills include generation and transmission charges for services that flow through PJM as well as distribution-level charges of each utility and, in some cases, additional charges from competitive retailers. Those distribution charges are determined by each state public utility commission.

The Energy Transition

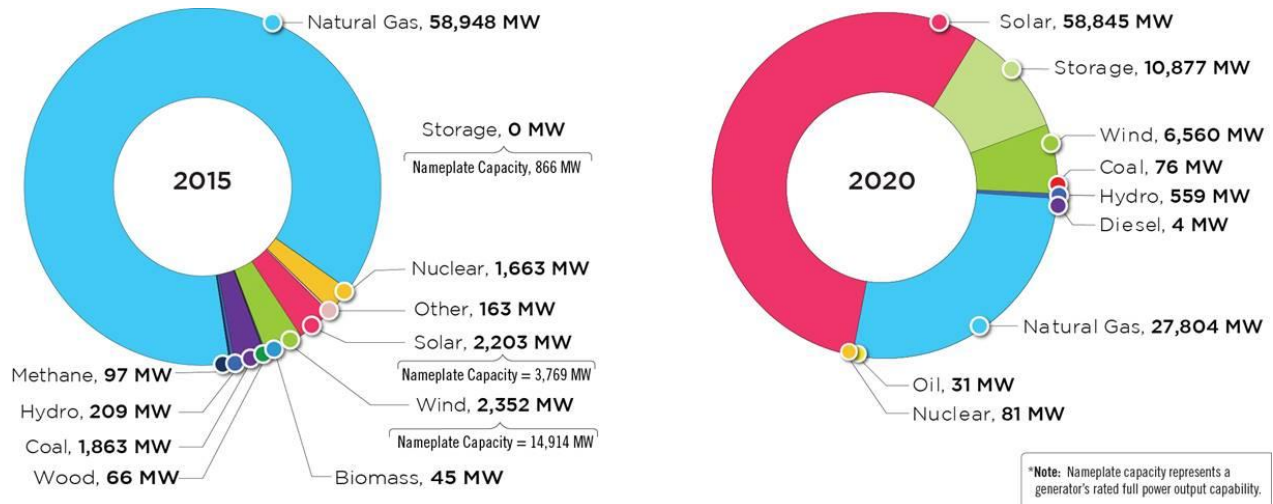
The transition to a more decarbonized grid has been underway in PJM for the last 15 years. Emissions rates in PJM are down drastically since 2005 – CO₂ by nearly 40 percent, sulfur dioxide by 95 percent and nitrogen oxides by 86 percent, driven in part by a transition from coal to natural gas-fired generation.

Figure 4. PJM System Average Emission Rates



As a result of policy choices by some PJM states, evolving consumer preferences and technology advancements, this decarbonization trend appears to be accelerating. PJM’s interconnection queue, consisting of generator projects studying the possibility of development and interconnection into PJM’s grid, has expanded significantly and is dominated by wind, solar, battery or hybrid projects.

Figure 5. Profile of New Generation Seeking to Interconnect onto the PJM Grid



The continued move toward decarbonization of the electric sector is a reality that PJM is committed to help facilitate in a manner that ensures grid reliability and uses our regional scale and competitive markets, wherever possible, to deliver efficiency for customers. It is a change that has great promise to spur new innovative technologies that can support grid reliability.

Nevertheless, ensuring grid reliability through this transition will require deliberate and thoughtful effort and partnership by and among several parties, including PJM, our states, our transmission and generation owners and other stakeholders, FERC and NERC. The transition drives us and our stakeholders to consider a number of overarching issues, including:

- As we see an increasing level of intermittent resources in the supply portfolio serving PJM customers, we could face energy prices falling significantly, due to declining marginal costs and the fact that these resources using the wind or sun to generate power effectively have no fuel costs. At the same time, we will need to ensure adequate compensation mechanisms for the back-up dispatchable generation – be it fossil generation or batteries – that will be needed given the intermittent nature of renewables. This may make the capacity market even more important in ensuring that we have adequate reserves. As an alternative, RTOs and ISOs could develop and provide compensation mechanisms for new flexible ancillary services. PJM has begun this process with FERC’s approval last year of our proposal to improve our overall pricing of reserves needed to maintain reliability each day.
- While the output of intermittent resources is less predictable on an individual unit basis, a substantial portfolio of such resources across a wide, diversified geography will contribute to the capacity needs of the system during peak periods. Along with our stakeholders, PJM is in the process of adopting a more accurate approach, called effective load carrying capability, to calculate the capacity value of intermittent resources during periods of peak demand. This will be an important component of our approach to reliability in coming years.
- Load forecasting, particularly in a post-COVID-19 environment, will prove to be more challenging. We have already made substantial improvements in our load forecasting within PJM. However, as we face the potential for more extreme weather, questions will be raised as to the extent to which we consider the possibility of extreme weather conditions dramatically affecting the demand for electricity, and the level of reserves that we need in order to “expect the unexpected.”
- The proliferation of “behind-the-meter” distributed energy resources can enhance reliability and provide customers with new self-help opportunities in times of system stress. However, for this to work well, we will need to ensure adequate visibility as the system operator and the ability, with customer consent, to dispatch those resources as a tool to ensure reliability. We have made a good start on this path through FERC’s Order 2222, but this effort will require a great deal of communication, coordination and cooperation among resource aggregators, customers, the system operator and the distribution utility.
- In today’s paradigm, we set reliability requirements to avoid a triggering event that could occur in the loss of load under a “one day in ten years” standard. However, as we have seen in many past situations, events such as extreme temperatures don’t often occur as simple stand-alone events. Rather, there is often a correlation of events, such as extremely cold temperatures coupled with ice storms, or the potential for multiple cybersecurity intrusions, for which we need to plan. Great strides have been made in how we drill and plan for these multiple events all hitting us at once, as I noted above. But the industry planning standards will need to continue to evolve to incorporate the potential for an increased correlation of multiple events occurring at the same time, and indeed, planning for more extreme scenarios is likely to come at additional cost, which will need to be carefully considered. This will require an increased focus from the industry as a whole as well, as by NERC and state and federal regulators.

I present these not as insurmountable challenges by any means, but as illustration of the need to coordinate the timing and substance of policymaking, industry evolution and technological development, so as to ensure that we continue to maintain a reliable power grid as we transition to a more decarbonized world.

Both the Congress and FERC play a key role in ensuring that the transition I described above occurs smoothly and enhances grid reliability. For one, we need to ensure that the laws and the decarbonization goals that Congress, FERC and the states set can be reliably implemented. The industry *can* adapt, and RTOs are an excellent vehicle – as are the markets they administer – to reflect those policies in investment signals that help develop a cleaner generation fleet. Communication between policymakers and grid operators will be key to crafting workable goals and laws going forward.

On the markets side, there will need to be regulatory support for accommodating state policies regarding the generation resource mix while also ensuring that we have the products (and adequate compensation to providers) in place, in a timely manner, to meet the reliability needs of the system going forward. We are presently involved in a series of workshops with our stakeholders on these very issues.

We are encouraged by a series of technical conferences which the Commission just announced to analyze the impact of climate change on ensuring a resilient grid. At the end of the day, although regional differences exist, policy direction would be helpful to ensure that all regions are working seamlessly toward the same goal using the same playbook and applying the same minimum standards. By the same token, modernizing the existing transmission system will provide a multitude of benefits, including designs that can withstand more extreme events, lower frequency and shorten duration of outages, reduce public and employee safety risks, and use advanced technology to improve system operability, efficiency and security.

In Conclusion

Thank you again for the opportunity to share PJM's perspectives on these important issues that face our nation.

In closing, I want to reiterate that the reliability and security of the bulk power system continues to be PJM's top priority.

As a large, interconnected grid, we ensure reliability through our markets, operations and regional transmission planning and through the significant efforts of our member companies. PJM is committed to accommodating state policy choices, and as we progress toward the Grid of the Future together, we must do so with reliability at the core of our common purpose and with careful consideration of the costs customers will be asked to pay.

And we look forward to working further with Congress, FERC, NERC and our partners across the energy industry, as well as our states and stakeholders, on additional actions to ensure reliability, affordability and resilience in a changing world.