

**Economic Commission for Europe**

Committee on Sustainable Energy

**Group of Experts on Cleaner Electricity Production from Fossil Fuels**

**Thirteenth session**

Geneva, 26 and 27 October 2017

Item 4 of the provisional agenda

**Workshop: Sustainable Management of Fossil Fuels in Electricity Generation**

# PJM Interconnection: A Case Study and Future Challenges

Author: Ms Heather Greenley, United States Energy Association

## Key Takeaways

- i. Electricity interconnections provide a diverse energy supply and lowers the cost of electricity for consumers
- ii. PJM ensures grid reliability through its independent and transparent business model
- iii. PJM's wholesale power markets, although still a topic debated by economists, continue to provide the best solution for cost-effective power based on economic merit, not fuel type.
- iv. PJM today is faced with new challenges of a retiring coal and nuclear fleet coupled with an increase in weather related grid disruptions
- v. Grid resiliency in the United States makes its way to the forefront of future planning for PJM, as PJM considers the security of the grid for many years to come

## Introduction

Providing access to reliable, affordable electricity continues to challenge even modern developed economics. Reliable, sustainable, power has been the paramount driving force of every nation's economic development. The United States electricity grid has set the precedent for reliability and affordability for electricity access all over the world. The success of the U.S. grid largely is attributed to the development of power pools, and there is no instance more famous than that of the PJM Interconnection. PJM enhanced energy security to its customers, by recognizing the need for a diverse fuel mix, diverse generation sources, and future planning with a coordinated fundamental understanding of competitive markets. Through ground breaking achievements by PJM, the electricity grid today operates fundamentally different than it did nearly event twenty-five years ago, putting increasingly safe, clean, reliable, and affordable power at the forefront of their business model.

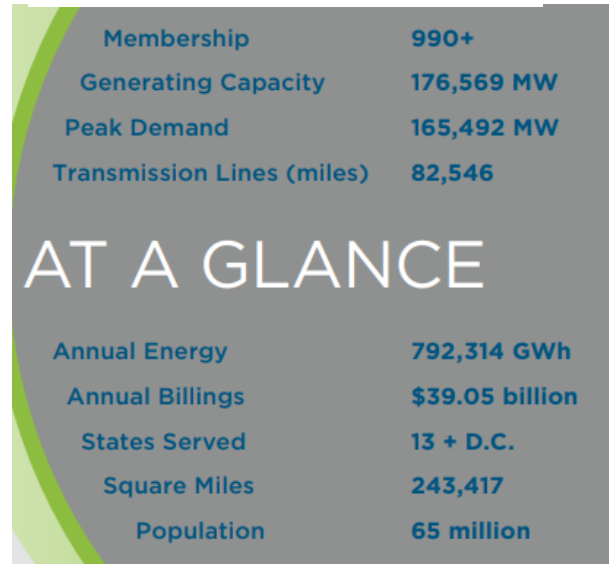
## A Brief History of PJM

This past September, the PJM Interconnection celebrated 90 years of ensuring competitive reliable power for the largest power grid in the United States. Since PJM's inception, the organization has consistently led the way in ground breaking operations that have shaped the entire electric power industry. Formerly known as the Pennsylvania-New Jersey-Maryland Interconnection, the organization established the world's first continuing power pool in 1927 as a way to better integrate a diverse energy mix, to reduce costs, and to enhance reliability for their customers.

At its core PJM's success rests on its independent and transparent structure. By 1993 the PJM Interconnection Association was established opening membership to non-utilities led by an elected Board of Managers. In 1997, PJM became the first Federal Energy Regulatory Commission (FERC) approved independent system operation (ISO) which granted PJM access to operate but not own transmission systems. This separation gave PJM a strategic advantage to focus on customer needs without bias of infrastructure ownership. PJM later became the first regional transmission organization (RTO) in 2002 when FERC sought to establish competitive generation with open access to transmission.

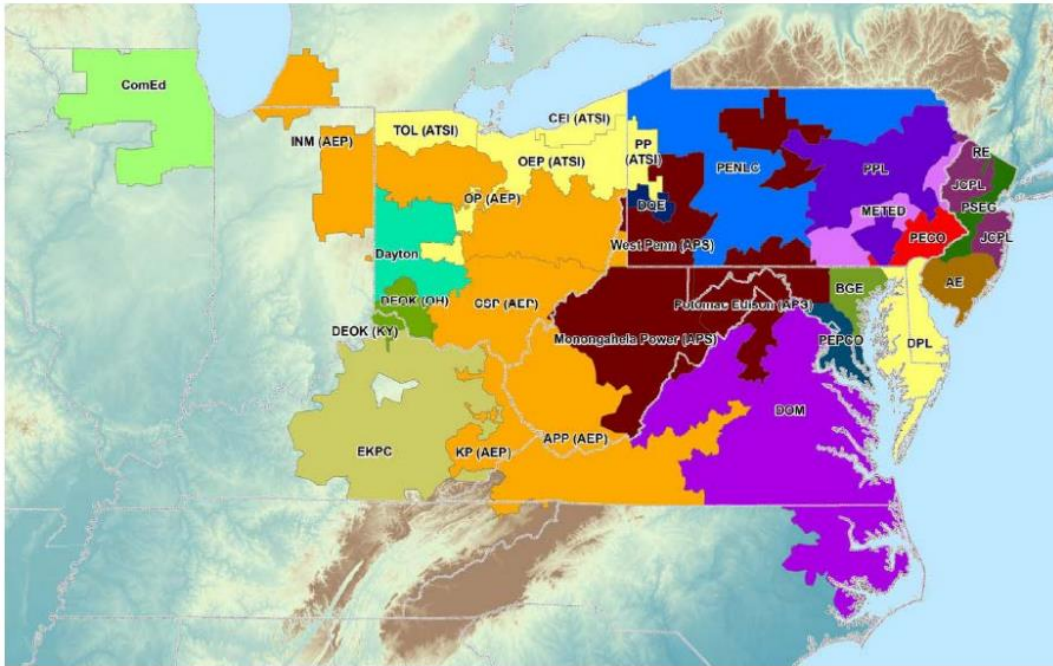
Within this framework, PJM has become one of the most successful interconnections in the world. PJM currently is responsible for providing power to over 65 million people across 13 states (Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia) as well as the District of Columbia, see Figure 2. This immense success is conceptualized in four main pillars: electric grid reliability, regional transmission system planning, lower costs, and furthering federal and state policy. These pillars have been adapted and established over the many years of PJM's existence to better manage grid operations and continues to evolve alongside the ever-changing grid.

FIGURE 1 PJM 2016 STATISTICS



Source: <http://www.pjm.com/-/media/about-pjm/newsroom/annual-reports/2016-annual-report.ashx?la=en>

FIGURE 2 PJM FOOTPRINT AND LOCATIONAL DELIVERABILITY AREAS



Source: <https://www.ferc.gov/market-oversight/mkt-electric/pjm/elec-pjm-footprint.pdf>

## Reliability

As an RTO, PJM balances the flow of supply and demand for electricity producers and users in both real-time and day-ahead bids resulting in pricing data within time intervals as short as 5 minutes.<sup>1</sup> This complex, real-time market, requires advanced technology and monitoring solutions to limit outages. “One software application processes 133,385 data points every 10 seconds and evaluates almost 6,300 potential problems every minute” providing system operators necessary information that could prevent disruption of the system.<sup>2</sup> PJM works closely with the North American Electric Reliability Corporation (NERC) to safeguard uninterrupted and coordinated services.

## Regional System Planning

PJM’s continued success hinges on its ability to plan for the future needs of the grid in order to service its customers. The planning process, known as the Regional Transmission Expansion Plan (RTEP), forecasts up to 15 years out, and includes mechanisms for analysing future grid upgrades, maintenance, new generation, and incorporating new transmission systems. PJM’s planning works to identify which upgrades will result in an economic benefit and if they could solve reliability issues.<sup>3</sup> One of the most difficult challenges facing PJM today is the fleet of baseload power expected to retire in over the next few years, which will be discussed later in this paper. Incorporating new regions too enhances reliability but also needs careful consideration. PJM continues to account for this potential growth and encourages

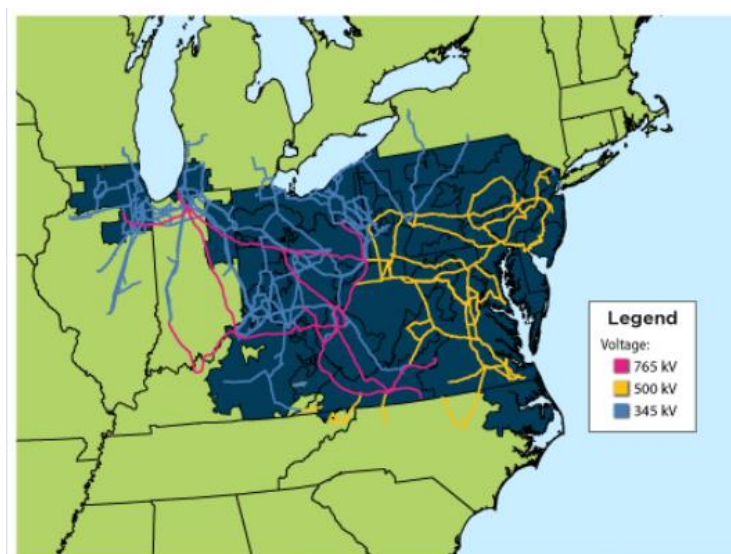
<sup>1</sup> U.S. Energy Information Administration, *About 60% of the U.S. electric power supply is managed by RTOs*, *Today in Energy*, 4 April 2011.

<sup>2</sup> <https://www.pjm.com/~media/about-pjm/newsroom/fact-sheets/pjm-at-a-glance.ashx>

<sup>3</sup> Zhenyu Fan, Tim Horger, and Jess Bastian, “Current and Emerging Challenges in PJM Energy Market,” <http://home.engineering.iastate.edu/~jdm/ee553/PJMmarket.pdf>

it as the incorporation of new regions often reduces energy prices for PJM customers at large. Interconnected grids benefit diverse population hubs, where generally large population centers that have higher electricity demands often are too dense for new power plants. Interconnection therefore, allows for the transmission of power from smaller less densely populated regions lush with electricity to those with high populations and rising demand. In order to accommodate the interconnected system, PJM serves a group of high-voltage transmission lines that are the foundation for the grid, Figure 3. Analyzing this transmission network can help determine where new generation could be incorporated and how to share upgrades.

FIGURE 3 PJM BACKBONE TRANSMISSION AND VOLTAGE



Source: <https://learn.pjm.com/three-priorities/planning-for-the-future.aspx>

## Wholesale Power Markets

PJM runs the world's largest competitive wholesale power market, and has done so with the foundation that wholesale markets balance and price resources to best meet customer needs. PJM's wholesale markets are based on competition, transparency and independence. While there still remains a debate on the benefits of wholesale markets, there is evidence to suggest that the market does incentivize competition which results in efficient lower production costs. This is illustrated by the consistent drop in wholesale electricity prices year-after-year. These prices are fully transparent and available to suppliers and buyers of power reflected in retail prices. PJM's market operates with buyers and sellers submitting bids for each hour then the market is resolved once supply and demand match. The bids are ordered with the lowest to the highest needed to satisfy the demand and the last unit is used to set the price for all other supplies left in the market.<sup>4</sup> The debate centers on this final pricing mechanism which some argue actually inflates market prices, contrary to PJM's intent; however, this has been disputed by many economists stating that these uniform prices do not actually result in higher prices for electricity, but that fuel price is the greatest impact to electricity prices. The power markets not only result in better prices for consumers but also provides for a more diverse electricity grid as the wholesale

<sup>4</sup> Pennsylvania Public utility Commission Motion concerning Polices to Mitigate Potential Electricity Price Increases, Comments of PJM Interconnection, LLC, Docket No. M-00061957

market does not discriminate against any fuel source. PJM solely ranks resources based on their economic merit and ability to provide electricity when dispatched.

## Generation and Government Policy

PJM consistently works to comply with and incorporate government policies that often impact electricity generation. In 2005, PJM developed the Generation Attribute Tracking System (GATS) that follows emissions from generators and creates a certificate for megawatts produced in order to prove government compliance. This certificate system allows for generators to sell to those that need clean energy and buy from those producing. PJM also can calculate a more representative illustration of capacity values for renewables. Each state can have their own standards and regulations and it is PJM's responsibility to incorporate those considerations when planning for the future grid and when operating the wholesale market.

## Trends and Challenges for PJM

### Plant Retirement

The U.S. electricity grid has recently faced a number of reliability challenges as a result of extreme weather but due to interconnections like PJM, customers often saw relatively minimal power disruptions. For example, during the polar vortex of 2014, American Electric Power Co. dispatched 90 percent of its soon-to-retire coal fleet to service their customers while natural gas infrastructure froze rendering them inoperable due to the weather conditions.<sup>5</sup> However, many of these coal and nuclear plants that provide reliability with onsite fuel sources are faced with the stark reality of their retirement due to the inability to compete economically. In 2010, PJM "identified approximately 12,000-19,000 MW of coal-fired generation that may be at risk of retirement....this range of potential generation at risk represents 7-12% of the installed generation capacity in the PJM region."<sup>6</sup> Furthermore, exacerbating the retirement of these plants, according to Moody's Investors Service, "PJM's latest forecast report indicates load has declined over the last decade, with system load falling to 790 TWh in 2015 from 822 TWh in 2005. It projects that coal plants running at a 40% capacity factor will be forced to close. About 7 GW of coal capacity are at high risk, and may be forced to run at 38% capacity factor it suggests. Another 12 GW, running at a capacity factor of 58%, would face a 'medium' risk."<sup>7</sup> The U.S. electricity grid has seen tremendous changes in the last decade alone, owing largely to the shale gas revolution, prices for natural gas and support for cleaner burning fuels has sent natural gas generation soaring, as evidenced by Figure 4.

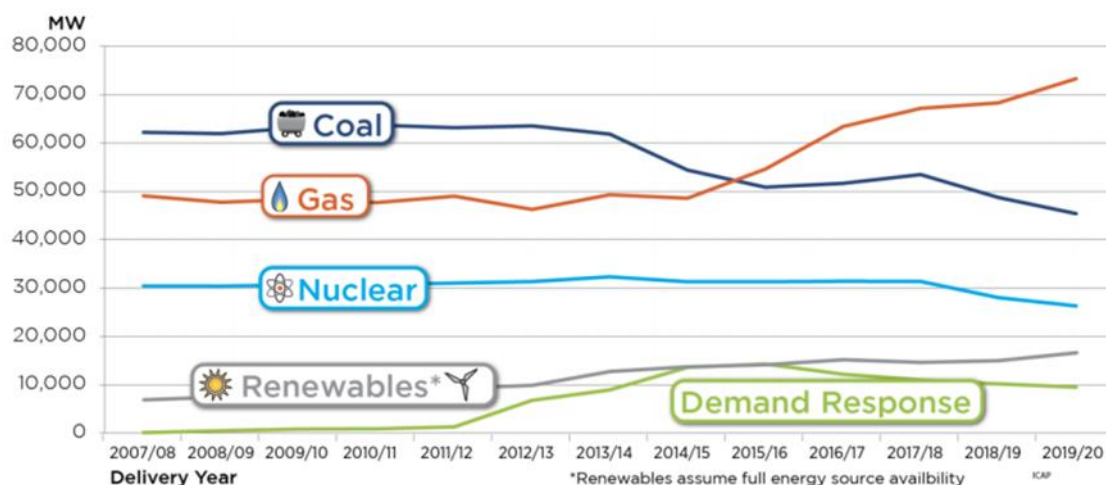
---

<sup>5</sup> Peter Behr, "Can coal and nuclear save the grid?" *E&E News*, 25 August 2017.

<sup>6</sup> PJM Interconnection (PJM), Appendix H, 2010 ISO/RTO Metrics Report, p. 303.

<sup>7</sup> Sonal Patel, "OJM Auction Signals trouble for Nuclear, Coal, and Even Renewables," *Power Magazine*, 24 May 2017.

FIGURE 4 PJM CLEARED INSTALLED CAPACITY BY DELIVERY YEAR



Source: <http://www.pjm.com/~media/library/reports-notice/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx>

## Resiliency

The hallmark of the PJM wholesale power market is that it operates independent of generation discrimination. PJM's determinations are based entirely on prices; for example, if a plant cannot produce electricity at a competitive price then that generation does not make the cut. This free market system however, can be at odd with PJM's equally important pillar—reliability. In the event of similar extreme weather or other grid disruptions, would PJM be able to operate without the soon-to-retire coal and nuclear fleet? U.S. Secretary of Energy, Rick Perry, recently has presented this question to FERC, and offered the need to consider, “grid resiliency” in power markets and suggested that owners of these plants be compensated for the value of having on-site fuel availability. While this consideration is not new, it has resurfaced with urgency as the grid and these retirements become ever more evident. PJM has moved to incentivize plant owners to assure fuel supplies either through rewards or meeting goals or failing to do so.<sup>8</sup> PJM has in the past proven through series of tests that it is able to maintain grid reliability even with massive additions of wind or solar, but only with the assumption that resources were provided from other sources. In fact, these tests illustrated that flexibility and response increased only at the expense of reliability.<sup>9</sup> According to Secretary Perry, “we must utilize the most effective combination of energy sources with an ‘all of the above’ approach to achieve long-term, reliable American energy security.”<sup>10</sup> PJM agrees that the grid has evolved, and reliable power isn't as simple as it once was, while today the grid faces this need for resiliency. “Resilience is the ability of the grid to withstand or bounce back quickly from all events that pose additional operational risks. These risk

<sup>8</sup> Peter Behr and Hannah Northey, “Perry's policy review pivots on grid resiliency,” *E&E News*, 24 August 2017.

<sup>9</sup> *Ibid*

<sup>10</sup> [https://www.eenews.net/assets/2017/09/29/document\\_pm\\_01.pdf](https://www.eenews.net/assets/2017/09/29/document_pm_01.pdf)



range from extreme weather to earthquakes, cyber and physical attacks, and events not yet imagined.”<sup>11</sup> In a paper released in April 2017, PJM argues the need to address questions surrounding the grid’s resiliency and how to achieve these goals making resilience possible criteria for system infrastructure. PJM further defines resilience as, “the capability of an energy system to tolerate disturbance and to continue to deliver energy services to consumers.”<sup>12</sup> The issue of resilience however, has not been solved, but only brought to the forefront of planning discussions. If resilience should become criteria how will it be implemented? PJM continues to seek answers to these questions and will move toward implementing the necessary actions in order to sustain the grid.

## Conclusion

Despite the aforementioned challenges, PJM has throughout its 90 year history proven its success. PJM not only will meet these challenges with neutrality and transparency, but also will likely yet again transform the way electricity markets operate today all over the world. Today’s grid is nothing like the one that PJM started with in 1927 and tomorrow’s grid also be different, but it is the result of PJM’s future planning that continues to keep the lights on for over 65 million customers. PJM’s example is one of an organization that truly puts customers first, and is willing to take informed risks and make efficient changes only if the outcome could benefit the customer or economically improve efficiency. PJM throughout its history has time and time again been the first to develop new standards, and time and time again it will continue to do so.

---

---

<sup>11</sup> PJM CEO and President Andrew L. Ott, “PJM Conference on Grid Resilience Explores New Challenges to Grid Security,” 20 September 2017.

<sup>12</sup> <http://www.pjm.com/~media/library/reports-notice/special-reports/20170330-pjms-evolving-resource-mix-and-system-reliability.ashx>