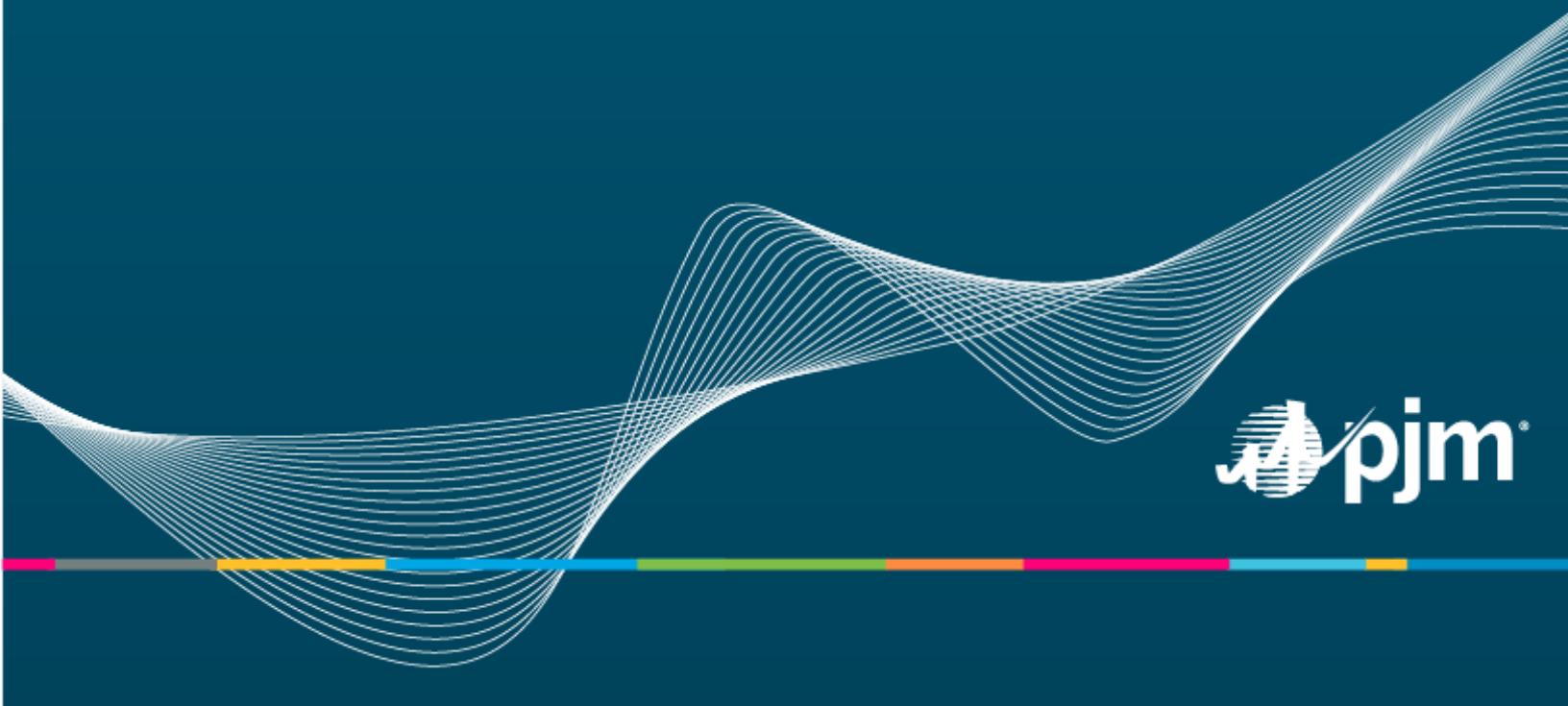
Perspective and Response of PJM Interconnection to

National Energy Technology Laboratories Report Issued March 13, 2018



This page is intentionally left blank.

Contents

Executive Summary

In March 2018, the U.S. Department of Energy's National Energy Technology Laboratory (NETL) released a report[1] assessing electric operations in the nation's Independent System Operators (ISOs) and Regional Transmission Organizations (RTOs) during a prolonged cold snap from Dec. 27, 2017–Jan. 7, 2018. In part, the report focuses on operations in the PJM Interconnection service area. PJM appreciates NETL's overall attention to system performance of each of the northeastern RTOs and ISOs during this period. PJM presents this report to review for the public the analysis undertaken by NETL and the conclusions reached.

PJM believes that the NETL report, as it relates to PJM, reaches some sweeping conclusions that are not supported by the specific facts concerning grid operations during Dec. 27, 2017–Jan. 7, 2018. Although the NETL report contains some appropriate analysis and asks valid questions, the report's overall conclusion is incorrect about the reasons for PJM's dispatch of coal units during the cold snap. PJM dispatched coal units because *their costs were lower* during certain hours of the cold snap. Natural gas and nuclear units were not unreliable or otherwise unavailable to serve the increased customer demand, nor would PJM have faced "interconnect-wide blackouts" without the particular generating units dispatched, as the NETL report claimed. For example, in its Executive Summary, the NETL report reaches the following conclusion:

> *"In PJM, the largest of the ISOs, coal provided the most resilient form of generation, due to available reserve capacity and on-site fuel availability, far exceeding all other sources (providing three times the incremental generation from natural gas and twelve times that from nuclear units); without available capacity from partially utilized coal units, PJM would have experienced shortfalls leading to interconnect-wide blackouts."*
> Executive Summary at p. 1.

PJM agrees that the report underscores the importance of a fuel-secure generation fleet to serve future demands. But in PJM's view, the report erroneously concludes that the relative *economics* of coal and nuclear vs. natural gas during the cold snap, which drove the dispatch of coal units (i.e., that the cost of coal was lower), indicates that the system would have faced "shortfalls leading to interconnect-wide blackouts" during this period. As PJM demonstrated in its own report[2] on system performance during the cold snap, PJM had adequate amounts of resources to supply power – the price of natural gas relative to coal and nuclear during the cold snap drove the dispatch decisions.

During the cold snap, the region experienced an increase in the price of natural gas, which made coal resources (which often did not run under periods of lower natural gas prices) the more economic choice during times of high gas prices. But one cannot extrapolate from these economic facts a conclusion as to future reliability within PJM.

[1] Reliability, Resilience and the Oncoming Wave of Retiring Baseload Units, Volume I: The Critical Role of Thermal Units During Extreme Weather Events; NETL; Mar. 13, 2018; https://www.netl.doe.gov/energy-analyses/temp/ReliabilityandtheOncomingWaveofRetiringBaseloadUnitsVolumeITheCriticalRoleofThermalUnits_031318.pdf

[2] PJM Cold Snap Performance: Dec. 28, 2017 to Jan. 7, 2018; PJM Interconnection; Feb. 26, 2018; at p. 32; http://www.pjm.com/-/media/library/reports-notices/weather-related/20180226-january-2018-cold-weather-event-report.ashx

PJM acknowledges that fuel security is a topic deserving increased focus. PJM has already taken steps to increase fuel security through many initiatives that have been implemented with approval of the Federal Energy Regulatory Commission (FERC), including its Capacity Performance reforms to its Reliability Pricing Model capacity market. These changes, designed to more clearly define the obligations of capacity resources to be available when called upon (and to secure adequate fuel supplies to do so) with stiff penalties for non-compliance, were a key first step in ensuring fuel security among those resources that PJM counts on to ensure reliability.

PJM is committed to further action to adequately value and price fuel-secure resources. PJM intends to pursue these initiatives in a manner that does not choose one particular fuel type over another. Instead, PJM will rely on a clear definition of attributes, and the adoption of market-based mechanisms to price those attributes, in order to drive competitive and efficient results that ensure the continued supply of reliable electricity to meet the region's needs at the lowest reasonable cost. PJM looks forward to working with its stakeholders, the Department of Energy (DOE) and the FERC on these initiatives.

PJM's View — Key Points:

- Defining Resilience: When using the term "resilience," the NETL report mixes the availability of adequate generation to meet load with the costs of particular resources in a given hour and their impact on economic dispatch. In essence, the NETL report attempts to quantify "resilience" by comparing the dispatched resource mix by fuel type during a mild demand period to the dispatched resource mix by fuel type during the cold snap period. The report then labels the incremental change in resource fuel types supplying electricity during the cold snap period as "resilience," implying resource availability was physically impaired, which led to a shift in dispatch during the cold snap between coal and natural gas.

  However, as noted above, the driver of the higher dependence on coal during the cold snap was the economics (i.e., lower cost) of coal vs. natural gas on an hour-by-hour basis.

  PJM's dispatch is designed to ensure both reliability of supplies and competitiveness of prices for customers. PJM does this by "stacking" bids of the units bidding to serve customers in a given interval and only dispatching those units needed based on the lowest cost resources available to meet demand. During a number of hours of the cold snap, coal resources were more economic (i.e., less expensive) than natural gas resources.

  This is a "good news" story for coal resources from an economic viewpoint, but the fact that additional coal resources were dispatched due to economics is not a basis to conclude that natural gas resources were not available to meet PJM system demands or that without the coal resources during this period the PJM grid would have faced "shortfalls leading to interconnect-wide blackouts."

  In fact, during the cold snap, PJM reserves were over 23 percent of peak load demand, and there were few units that were unable to obtain natural gas transportation, even for most units that relied only on interruptible service.

  NETL also makes the argument that offline coal, which came online "suddenly" during the cold weather, acted as adaptive resilient generation. 57 percent of coal generation was self-scheduled and 41 percent was scheduled based on economic offers – largely due to the lower cost of coal vs. gas. By the same token, any natural gas units

that were available[3] but not scheduled were counted as offline reserves and, therefore, can also be considered adaptive resilient generation. This is the primary mechanism PJM uses to make reserves available on the system. Those resources that are the most economic (i.e., lowest cost) to provide energy are dispatched to do so, while more expensive resources are held offline and provide reserves. For the peak day of Jan. 5, 28,883 MW of natural gas were available but not scheduled as energy or reserves. These units can also be considered as adaptive reserves using the NETL approach.

- Emergency Procedures: PJM's emergency procedures process signals system operators to perform specific actions if system conditions have the potential to deteriorate. Leading up to and during the 2017/2018 cold snap, PJM did not enter into conservative or corrective emergency actions to address capacity or reserve shortages.

- Forced Outages: NETL attributes the increase in coal usage to potential issues related to natural gas fuel supply. Generation outages due to fuel supply issues were not prominent. Jan. 5, 2018, hour-ending 1900, the PJM system hit its peak demand during the cold snap period of 137,522 MW. At that time, PJM experienced 2,680 MW of outages due to fuel supply, 2,181 MW of which were related to natural gas supply. This represents a relatively small portion of the total 16,671 MW of all generation was forced offline during that time.

- Available Capacity and Operating Reserve Margins: NETL does not identify the level of system reserves available to operators during the cold snap period. The PJM system had 32,645 MW, or 23 percent, of additional capacity available to serve demand during the peak demand of the cold snap period. As illustrated graphically below, PJM's Operating Reserves market, a time-based reliability product for maintaining and dispatching reserves quickly, also maintained sufficient levels throughout the period.

Emergency Procedures

PJM's Emergency Procedures[4] identify the instructions, rules, procedures and guidelines for the operation of the region's bulk electric system[5]. Under more extreme system conditions, PJM's Emergency Procedures include actions by which PJM would declare capacity or reserve emergencies and subsequent remedial steps.[6] For instance, PJM is able to recall off-system sales of energy from resources committed to serve the PJM region. Leading up to and during the cold snap event, PJM entered into Cold Weather Alerts[7] and High Load Voltage Schedule Warnings and Actions.[8] Neither procedure

[3] Available units are mechanically able to operate but may not be scheduled based on economics. A simple call to those units would get those units operating on the system.

[4] PJM Manual 13: Emergency Operations; PJM Interconnection; v.65 effective January 1, 2018; http://www.pjm.com/~/media/documents/manuals/m13.ashx

[5] At times of actual or potential emergency conditions, PJM will issue emergency procedure notifications ranging in severity from informational alerts and warnings to critical system actions.

[6] *Id. Section 2, p. 16*

[7] Cold Weather Alerts serve to notify members of higher-than-normal demand, notify asset owners to restore all available transmission and generation equipment, and notify asset owners to defer any maintenance activities planned during the alert period.

represents a capacity or reserve shortage condition. The PJM market did not enter a Performance Assessment Interval. Performance Assessment Intervals are time periods when emergency conditions require capacity committed to serve the PJM market to perform to their committed, prescribed level or suffer significant financial penalty.

Economic Dispatch

As described above, through economic dispatch, PJM uses the lowest cost set of resources to serve demand at a given interval. During the cold snap, coal and oil resources became more economic than natural gas-fired resources when natural gas prices rose.

The average megawatt contribution by fuel type for the morning (Figure 1) and evening peaks (Figure 2) of Dec. 1, 2017–Jan. 7, 2018 are shown below. The megawatts obtained from natural gas and nuclear capacity remain relatively stable in both periods. Coal and oil generation output increased.

The stable output of nuclear generation is expected because nuclear generation typically operates at its full capability whenever it is available. The increase in output from coal and oil is attributable to the economics of the supply offers into the market. Figure 3 shows the supply offers of available resources. The dashed lines represent coal and gas offers from Dec. 1–26, 2017. The solid lines represent coal and gas offers during the Dec. 27, 2017–Jan. 7, 2018 cold snap period.

While coal offers remained relatively consistent between the two periods — in the $0–30/MWh range — during mild system conditions, considerable contributions of natural gas are more economic than some coal resources. Progressing to the elevated demand period during the cold snap, the supply curve for gas resources shifts as fuel becomes more expensive, making coal (and oil) resources more economic to operate.

[8] Heavy Load Voltage Schedule Warnings and Actions alert transmission owners to energize all capacitors, remove all reactors and optimize voltage schedules to help maximize the power transfer capability of the system. By taking these steps, PJM ensures the system is positioned in the most resilient manner possible, allowing us to move power from one area to another if there are major generator or transmission failures. These procedures are issued proactively and do not signify any capacity or transmission concerns.

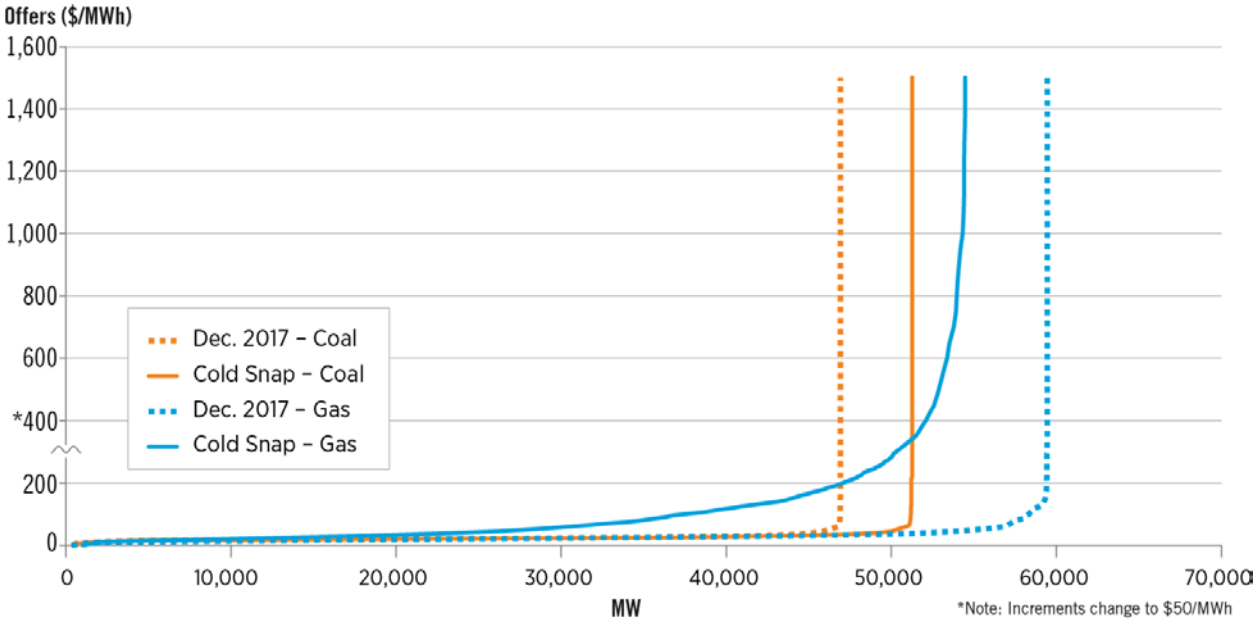
Figure 1. Average Morning Peak Megawatt Output by Fuel Type, Dec. 1, 2017–Jan. 7, 2018

Morning Peak Period – HE 0900				
	Average for Dec. 1–26, 2017		Average for Dec. 27, 2017–Jan 7, 2018	
Fuel Type	Average Per Hour (MW)	Total Generation (%)	Average Per Hour (MW)	Total Generation (%)
Coal	32,676	32%	45,506	37%
Gas	27,090	27%	27,600	23%
Hydro	2,415	2%	2,806	2%
Multiple Fuels	90	0%	376	0%
Nuclear	35,289	35%	35,448	29%
Oil	295	0%	5,855	5%
Other	61	0%	59	0%
Other Renewables	641	0%	728	0%
Solar	87	0%	89	0%
Storage	-	0%	-	0%
Wind	3,398	3%	3,030	3%

Figure 2. Average Evening Peak Megawatt Output by Fuel Type, Dec. 1, 2017–Jan. 7, 2018

Evening Peak Period – HE 1900				
	Average for Dec. 1–26, 2017		Average for Dec. 27, 2017–Jan 7, 2018	
Fuel Type	Average Per Hour (MW)	Total Generation (%)	Average Per Hour (MW)	Total Generation (%)
Coal	34,105	32%	45,922	37%
Gas	29,919	28%	29,242	24%
Hydro	3,320	3%	2,875	2%
Multiple Fuels	100	0%	385	0%
Nuclear	35,237	33%	35,440	29%
Oil	276	0%	5,815	5%
Other	37	0%	38	0%
Other Renewables	638	0%	741	0%
Solar	3	0%	1	0%
Storage	-	0%	-	0%
Wind	3,103	3%	3,138	3%

Figure 3. Avg. Incremental Generation Supply Offers by Fuel Type, Dec. 1, 2017–Jan. 7, 2018[9]



Forced Outages

Figure 4 shows that on Jan. 5, 2018, hour-ending 1900, PJM's peak demand day during the cold snap, PJM experienced a total of 16,671 MW of forced outages for all reasons. Data below shows that overall forced outages during the peak demand hour of the recent cold snap were about half what they were during the 2014 Polar Vortex.

Figure 5 shows that on Jan. 5, 2018, hour-ending 1900, PJM's peak demand day during the cold snap, out of the total forced outage MW PJM experienced 2,680 MW of outages due to fuel supply. 2,181 MW of fuel supply-related outages were due to natural gas supply. This represents less than 2 percent of the total load requirement at the time. During the cold snap period, PJM's highest experienced outages due to fuel supply occurred on Jan. 7, 2018, hour-ending 0900. At this time, 6,418 MW were unavailable to operators, with natural gas making up the majority of fuel type outages in this category. By contrast, forced outages due to fuel supply issues during the 2014 Polar Vortex peaked at roughly 10,000 MW.[10]

[9] 'Dec. 2017' represents the period prior to the cold snap experienced in PJM (Dec. 1 – 26, 2017). 'Cold Snap' represents the period during the cold snap experienced in PJM (Dec. 27, 2017 – Jan. 7, 2018).

[10] Analysis of Operational Events and Market Impacts During the January 2014 Cold Weather Events; PJM Interconnection; May 8, 2014; at pp. 24–25; http://pjm.com/~/media/committees-groups/task-forces/cstf/20140509/20140509-item-02-cold-weather-report.ashx

Figure 4. Forced Outages Due to Fuel Supply Issue by Fuel Type

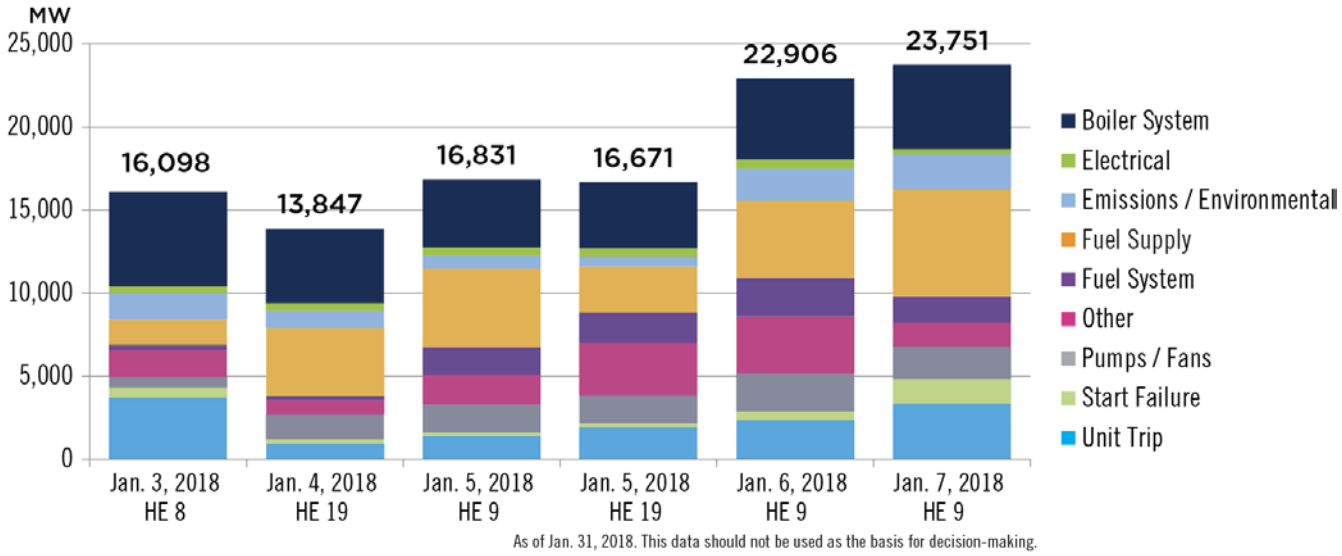
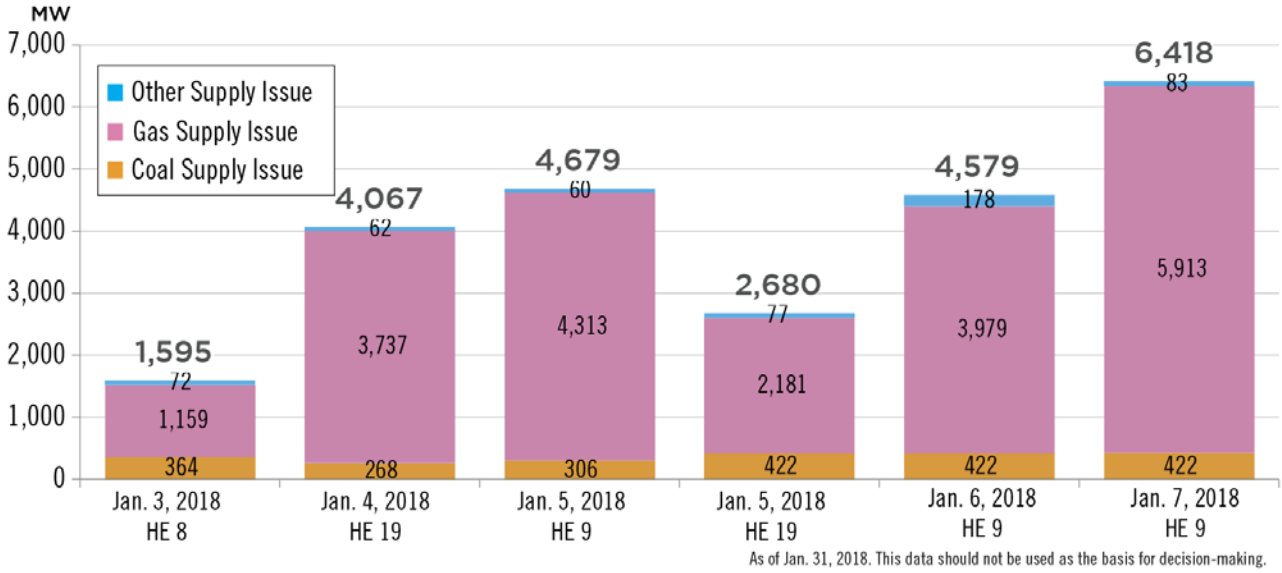


Figure 5. Forced Outage Causes



Available Capacity and Operating Reserve Margins

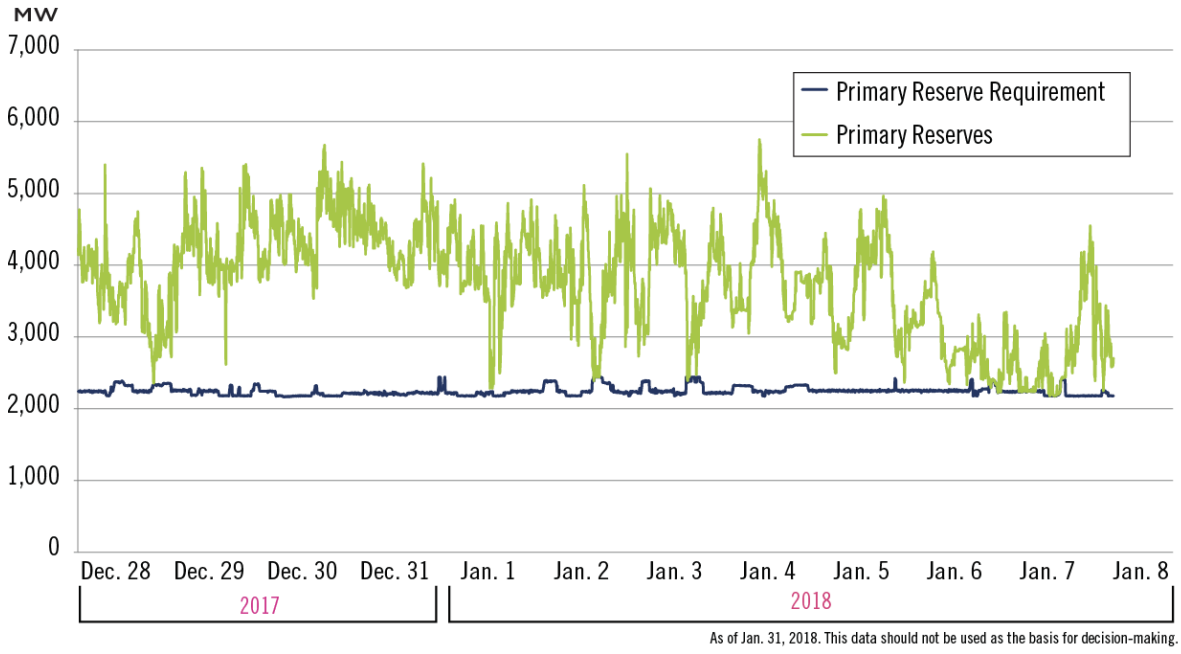
During the cold snap period, PJM maintained healthy reserve margins. Figure 6 illustrates that during the peak demand period of the cold snap period, PJM maintained more than a 23 percent reserve margin *above* the 18,690 MW of capacity that was unavailable. To put that into perspective, the PJM system had 32,645 MW of additional capacity available to serve demand.

Figure 6. PJM Available Capacity Reserve Margin, Jan. 5, 2018 HE 1900

PJM Cold Snap System Peak Period Jan. 5, 2018 HE 1900		
		Description
PJM Installed Capacity	188,875 MW	All PJM capacity market committed internal and external installed capacity (Includes wind and solar at unforced capacity ratings. Excludes energy-only units and any winter ambient uprates.)
All Outages	18,690 MW	Includes: All forced, maintenance and planned outages.
PJM Installed Capacity Available	170,167 MW	"PJM Installed Capacity" less "All Outages"
Demand	137,522 MW	The PJM peak demand during the cold snap period
Installed Capacity Reserve Margin	37.3%	"PJM Installed Capacity" divided by "Demand" less 1
Available Capacity Reserve Margin	23.7%	"PJM Installed Capacity Available" divided by "Demand" less 1

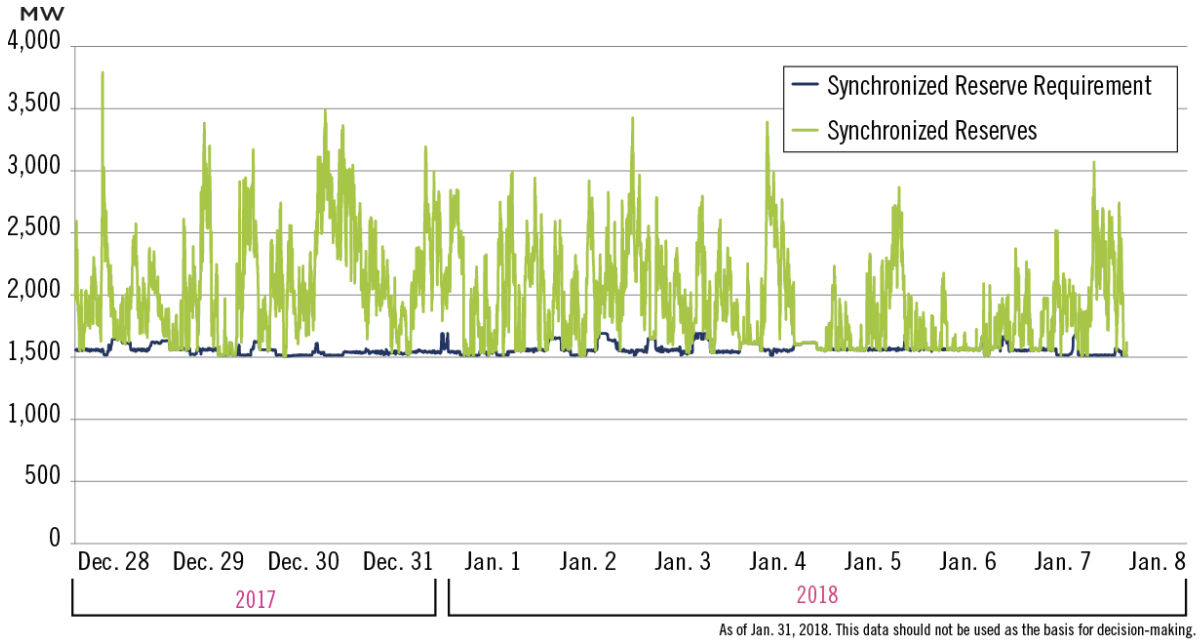
During the cold snap, PJM did not experience reserve shortage conditions. Sufficient reserves were available to meet both the contingency (primary) and synchronized reserve requirements as illustrated below. Figure 7 compares the contingency (primary) reserve values to the contingency reserve requirement and Figure 8 compares the synchronized reserves to the synchronized reserve requirement[11].

Figure 7. Contingency (Primary Reserves), Dec. 28, 2017–Jan. 8, 2018



[11] Primary reserves are the total quantity of resources both synchronized and not synchronized to the grid, assigned to respond within ten minutes when deployed. Synchronized reserves is a subset of primary reserves, and is comprised of only resources that are synchronized to the grid.

Figure 8. **Synchronized Reserves, Dec. 28, 2017—Jan. 8, 2018**



Conclusion and Next Steps

PJM noted in its previous report[12] on performance during the cold snap that thanks to the reliable operations from PJM members and operators, the system performed well in the cold snap, evidence that the grid in the PJM service area remains strong, diverse and reliable. In fact, PJM has implemented the Reliability Pricing Model and Capacity Performance as key steps to securing an adequate level of reserves with enhanced unit performance to mitigate the impacts of extreme weather and generator retirements resulting from environmental regulations.

Additionally, PJM noted that more work needs to be done to properly recognize and price key generator attributes associated with fuel security. NETL's report continues an important conversation to focus on the resilience of the nation's bulk electric system. In prior reports and filings with FERC, PJM has highlighted the importance of developing fuel security criteria that can be incorporated and priced in the PJM markets. PJM is also looking to add resilience drivers into its planning process and to enhance gas-electric coordination.

PJM has detailed both its own actions in order to enhance resilience and specific recommendations for action that it submitted to FERC in PJM's March 9 Comments in FERC's Grid Resilience docket (Docket No. AD18-7-000). PJM intends to continue communication with the DOE and with the FERC, states and stakeholders to underscore these needed actions and looks forward to working with the DOE to further focus efforts on ensuring a competitive market-based approach that ensures fuel security is appropriately valued in the markets.

PJM urges that the comments above be taken as a factual response to the conclusions reached in the NETL report. Most importantly, PJM appreciates NETL's contribution to focusing policymakers' attention on these issues going forward.

[12] *Id.*, *PJM 2017/2018 Cold Snap Report*