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Before the United States Senate Committee on Energy and Natural Resources
Washington, DC
"*The Performance of the Electric Power System Under Certain Weather Conditions*"

January 23, 2018

Introduction

Chairman Murkowski, Ranking Member Cantwell, members of the committee, I am Charles Berardesco, interim president and chief executive officer of the North American Electric Reliability Corporation ("NERC"). On behalf of NERC, I appreciate the opportunity to discuss the performance of the bulk power system[1] ("BPS") during the severe cold weather that gripped the eastern half of the United States and Canada over a two-week period in late 2017 and early 2018.

During the extreme cold, high electricity demand prompted activation of established procedures by industry to manage reliability risk and increased stress on the system. These procedures included conservative operations, cold weather alerts, and other special procedures to support continued reliable operation of the BPS. NERC, working closely with our Registered Entities[2] and federal partners monitors the BPS. Throughout this period, there were minimal observed impacts on the BPS. System stability was maintained; and the system operated reliably. Actions taken by NERC and Regional Entities[3] since the 2014 Polar Vortex contributed to reliability, underscoring the contributions of the Electric Reliability Organization Enterprise[4] ("ERO Enterprise") in promoting a continuous learning environment. As is the norm during extreme winter weather, cold temperatures did impact the system, thus highlighting the importance of a diverse and reliable fuel supply.

My testimony will discuss:

- How NERC's Bulk Power Situation Awareness ("BPSA") group monitors the BPS and works with stakeholders in industry and government.

[1] The "bulk power system" refers to facilities and control systems necessary for operating the interconnected electricity transmission network (generally 100kV and above), and the electric energy and services needed to maintain system reliability. It does not include facilities used in the local distribution of electric energy.
[2] "Registered Entities" refers to the more than 1,400 bulk power system owners, operators and users required to register with NERC and subject to mandatory reliability standards.
[3] The Regional Entities include Florida Reliability Coordinating Council, Midwest Reliability Organization, Northeast Power Coordinating Council, ReliabilityFirst Corporation, SERC Reliability Corporation, Southwest Power Pool RE, Texas Reliability Entity, and Western Electricity Coordinating Council.
[4] The "ERO Enterprise" refers collectively to NERC and the eight Regional Entities which have delegation agreements with NERC to perform compliance functions and other activities.

- The performance of the BPS during the extreme cold and how system owners and operators navigated challenges during that period.
- How the ERO Enterprise supports a continuous learning environment for industry, regulators, and policymakers.
- How our observations underscore NERC's recommendations regarding fuel diversity and fuel supply.

About NERC

NERC is a private non-profit corporation that was certified in 2006 by the Federal Energy Regulatory Commission ("FERC") as the ERO under Section 215 of the Federal Power Act (16 U.S.C. §824o). With oversight by FERC, NERC develops and enforces reliability standards; annually assesses seasonal and long-term reliability; monitors the BPS through system awareness; and educates, trains, and certifies industry personnel. NERC's Electricity Information Sharing and Analysis Center performs a critical role in real-time situational awareness and information sharing to protect the electricity industry's critical infrastructure against vulnerabilities. NERC has agreements with eight Regional Entities to which NERC delegates authority to perform certain functions. NERC's area of responsibility spans the continental United States, Canada, and the northern portion of Baja California, Mexico. Our jurisdiction includes users, owners, and operators of the BPS, which serves more than 334 million people.

NERC's Bulk Power System Awareness Group

NERC's Bulk Power System Awareness ("BPSA") group provides continuous monitoring of the BPS. During severe weather events, BPSA operates under an elevated status to closely monitor operating conditions. BPSA, in conjunction with the eight Regional Entities, collects and analyzes information across the 14 Reliability Coordinator ("RC") areas on system disturbances and other incidents that have, or could have, an impact on the BPS and disseminates this information to internal departments, Registered Entities, and governmental agencies. BPSA also monitors ongoing storms, natural disasters, and geopolitical events that may potentially impact or are currently impacting the BPS. The BPSA group also supports the development and publication of industry alerts and awareness products and facilitates information sharing among industry, Regions, and the government (U.S. Department of Energy, U.S. Department of Homeland Security, FERC) during crisis situations and major system disturbances.

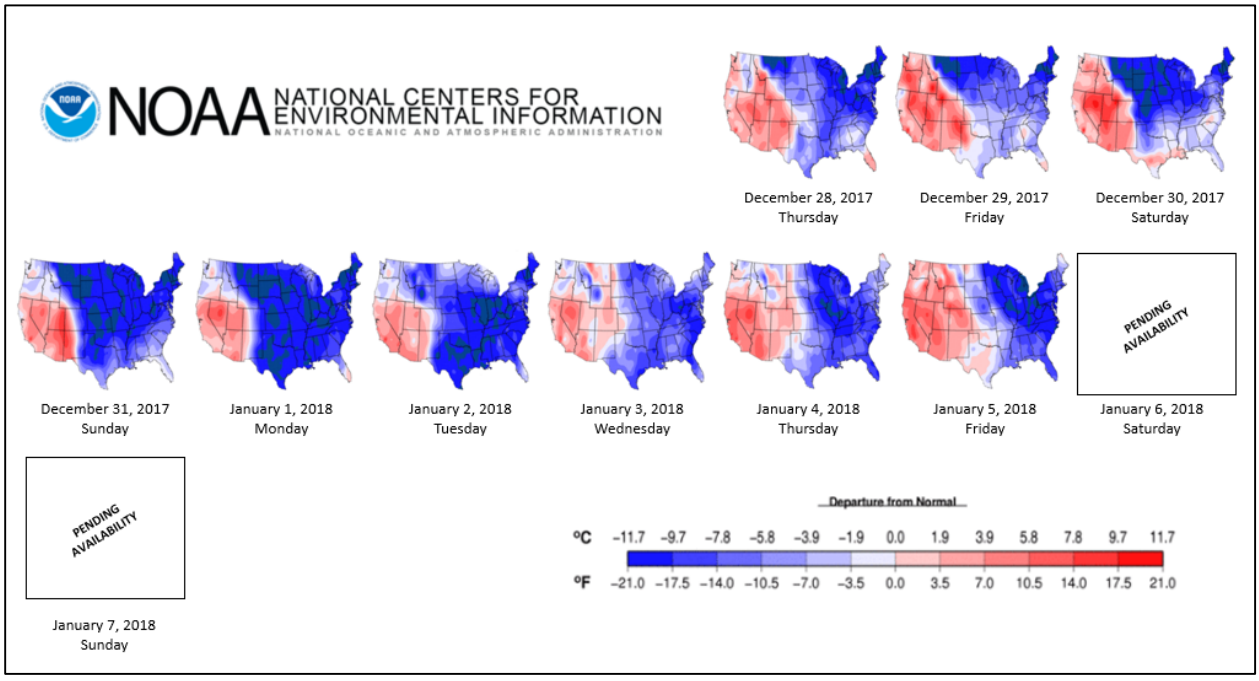
In short, BPSA is NERC's continuous "eyes and ears" on the system. During the recent severe cold weather, NERC BPSA held calls with its Regional Entities in the affected areas and gathered information from the Reliability Coordinators about concerns and issues associated with the impending storm. Multiple coordination calls were held daily with Regional Entities and FERC staff to further understand fuel levels, natural gas availability, and other factors such as fuel storage and replenishment plans, as well as dual fuel capabilities. This information was further shared with other government agencies and staffs. The NERC BPSA and affected Regional

Entities also conducted historical assessments, including high and low average temperature deviations and historical performance rates under similar weather conditions.

BPS Performance During the Extreme Cold Weather

The appendix details the performance of the BPS in eight Reliability Coordinator areas (including the Northeast and the Mid-Atlantic), load and fuel profiles, and measures implemented to manage the extreme weather. The following is a general overview of system performance and notable observations from system monitoring and analysis.

The BPS remained stable and reliable as a mass of extremely cold air moved into the eastern half of the United States, as far south as Texas and the Carolinas, during the last week of 2017 and first week of 2018. As the chart below indicates, temperatures ranged from 10° to 20° F or more below normal across most of the affected area from approximately December 28 through January 7. In contrast, the 2014 Polar Vortex saw widespread temperature departures 30° to 35° F below normal with widespread snow, ice, and freezing rain that drove a higher than desired rate of generation forced outages. [5]



There was no load loss due to BPS conditions or events during this most recent period of high loads and extreme cold. Reliability Coordinators in affected parts of the country implemented conservative operations and abnormal conditions emergency procedures and began heightened planning, communication and preparation as early as December 23. Although a nuclear power station in Massachusetts was forced offline due to a transmission system outage on January 4, overall, throughout the period, there were no significant events impacting the

[5] *See* Polar Vortex Review, NERC, September 2014.

transmission system, nor abnormally high generator forced outages. The primary challenge was reliably serving electricity demand during a period of near- and in some cases record-setting winter loads. A diverse generation mix with adequate flexibility and back-up fuel was key to meeting this increased electricity demand. All forms of generation contributed to serving load.

During the extreme cold weather, six Reliability Coordinators exceeded their forecasted 2017/18 winter peaks, some significantly so – Electric Reliability Council of Texas ("ERCOT") by 14.26%, Tennessee Valley Authority ("TVA") by 6.44%, and PJM Interconnection, L.L.C. ("PJM") by 4.38%. ERCOT also set a new all-time winter peak record, surpassing the previous record (which was set in January 2017) by over 3,200 MW.

While no records were set or peak forecasts exceeded, New England exhibited the greatest stress to the system. There, high natural gas prices combined with record setting consumption for heating and other non-power generation uses resulted in increased use of fuel oil for generation over the entire period. This increased consumption depleted inventories, the resupply of which was delayed in transportation due to the winter storm (reported in the media as the "bomb cyclone"). As mentioned, a nuclear power station in Massachusetts was forced offline due to a transmission system outage on January 4, removing 685 MW of baseload generation for several days. While reliability was maintained, this event further tightened the capacity situation across the New England ISO footprint until temperatures warmed, oil supplies were replenished, and the nuclear plant came back online on January 10.

Entities in the southeastern United States also experienced significantly stressed conditions, particularly in the VACAR South Reliability Coordinator footprint (most of North and South Carolina, and parts of surrounding states). These entities implemented a greater number and more significant emergency procedures than other areas, including use of a 5% system-wide voltage reduction to reduce loads during morning peak on January 2. While load shedding was not ultimately required, the portfolio of emergency procedures used by VACAR South RC were the closest to those employed during the 2014 Polar Vortex.

Overall BPS performance during the early 2018 cold weather events showed improvements over the past winters of similar or worse severity. In part, the improved performance observed so far reflects actions taken by stakeholders as a result of analysis, lessons learned, and implementation of recommendations from experiences in the 2011 Texas Cold Snap and the 2014 Polar Vortex. NERC and its stakeholder committees have worked with industry and the North American Generator Forum ("NAGF") to provide cold weather training materials that capture many of the lessons learned and share good industry practices in the mitigation of cold weather risks. In turn, the ERO Enterprise has used many of the resources in webinars, conferences, workshops, and outreach visits to educate industry about these risks. Many of these resources are shared publically on the NERC website[6].

[6] See *NERC's Cold Weather Training Materials*.

As recommended in the Polar Vortex Report, NERC and the Regional Entities continue to emphasize the need for thorough and sustained winter preparation to improve generation performance, as well as close coordination and communication between generator and system operators, particularly during peak winter demand periods. NERC and the regions, in close coordination with the NAGF, conduct annual workshops and webinars concerning winter weather preparation, and review each winter season or other extreme load periods for lessons learned or good industry practices to share across North America.

The Regional Entities are important to leveraging this work with industry at the regional level. For example, the ReliabilityFirst Corporation[7] ("RF") – whose footprint includes the Mid-Atlantic region – conducted 18 targeted on-site generating facility engagements since the Polar Vortex. These engagements are targeted at generating facilities that have experienced freezing or cold weather-related issues during prior winters, and new generating facilities. RF explains and discusses winter preparedness challenges with the entity; identifies and shares best practices; reviews the entity's winterization plan implementation records; and conducts walk-throughs of areas of the facilities susceptible to extreme weather challenges. RF utilizes cross-functional teams of experts to conduct these engagements (expertise in facility operations, maintenance, engineering, and planning). During the generating facility engagements, RF also verifies that the facilities have remedied previously identified winterization challenges. Such challenges have included issues with frozen valves and clogging of combustion turbine inlet filters with snow. In addition to these activities, RF conducts educational meetings and conference calls with entities within the RF region, biannual reliability workshops, reports on best practices, and consultation and information sharing with NERC. There have been improvements in cold weather performance each year in the RF footprint since the Polar Vortex, such as reduced outages and increased reserves.

In the Northeast, the Northeast Power Coordinating Council ("NPCC") routinely conducts operational coordination conference calls with Reliability Coordinators within the region. These calls provide a forum to communicate the status of current operating conditions, to facilitate the procurement of emergency condition assistance, and to enable sharing of information regarding potential threats to the system. In advance of and during the most recent winter storm and extreme cold weather, NPCC administered a number of pre-emergency preparedness calls to support programs that provided for additional system resiliency and security in the event of multiple contingencies during critical periods. Other Regional Entities have pursued activities similar to RF's and NPCC's in order to promote a strong learning environment with industry. Overall, in part due to the efforts of NERC and the Regional Entities, NERC's *2017 State of Reliability* report shows improvement in winter generator availability.[8]

[7] ReliabilityFirst Corporation footprint stretches from the eastern Great Lakes to the Eastern Seaboard and includes 13 states and the District of Columbia. See Regional Entity map here.
[8] *See* 2017 State of Reliability, NERC, June 2017.

NERC's Reliability Standards also require industry to prepare for and mitigate emergencies from extreme weather. In particular, Emergency Operations Standard-011-1 ("EOP-011-1") addresses the effects of operating emergencies by ensuring each Transmission Operator and Balancing Authority has developed operating plans to mitigate emergencies, and that those plans are coordinated within a Reliability Coordinator area. Among other factors, operating plans must include reliability impacts of extreme weather conditions.

Key Findings and Recommendations from NERC Assessments Related to the Cold Weather

During the extreme cold period, natural gas and oil-fired generation (in New England especially) were increasingly called upon to provide needed power. Increased reliance on natural gas and oil during severe weather conditions underscores the importance of recommendations in NERC's recent assessments.[9] In its long-term reliability assessments, NERC identifies how reliance on a single fuel increases vulnerabilities, particularly during extreme weather conditions. Against a backdrop of low natural gas prices and policies that promote increased natural gas generation, regions of the country have significantly increased dependence on natural gas over the past decade. Four of NERC's assessment areas now meet their peak electric demand with greater than 50 percent of that sourced from natural-gas-fired electric generation.[10]

Recognizing these trends, it is important to continue learning from extreme events to further enhance reliability for the future as we have learned from the 2014 Polar Vortex. During the Polar Vortex, extended periods of cold temperatures caused direct impacts on fuel availability, especially for natural-gas-fired generation. Higher-than-expected forced outages and common-mode failures were observed during the Polar Vortex due to the following: 1) natural gas interruptions (including supply injection), compressor outages, and one pipeline explosion, 2) oil delivery problems, 3) frozen well heads, 4) inability to procure natural gas, and 5) fuel oil gelling. Because natural gas provides "just-in-time" fuel and is not stored on site at generators, maintaining firm transportation and dual fuel capability can significantly reduce the risk of interruption, common-mode failure, and widespread fuel delivery impacts.

NERC's 2017/2018 Winter Reliability Assessment observes an increasing trend since 2012 of natural gas-fired generation outages during winter months.[11] These historical outages that resulted from fuel unavailability during the winter months underscore the need for fuel assurance and operational readiness during periods when reliance on natural gas can be critical.

While the recent extreme cold weather period was less severe than the 2014 Polar Vortex, observations from both events do point to a number of recommendations that NERC makes in recent assessments.

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[9] *See* Special Reliability Assessment: Potential Bulk Power System Impacts Due to Severe Disruptions on the Natural Gas System, NERC, November 2017, *and* 2017 Long-Term Reliability Assessment, NERC, December 2017.
[10] *See* 2017 Long-Term Reliability Assessment (pg 15), NERC, December 2017.
[11] *See* 2017/2018 Winter Reliability Assessment (pg 13), NERC, November 2017.

Reliable Fuel Supply – Natural gas supply and transportation were highly reliable throughout the extreme cold period, yet reliable natural gas supply and transportation must remain a high priority. In the Northeast, for example, natural gas generation was unable to access natural gas due to the interruptible nature of the fuel transportation agreements with natural gas pipelines and the limited pipeline capacity available in the region. High natural gas prices also caused a shift away from natural gas and to fuel oil. New England is highly dependent on oil fuel to use as a back-up in the event of extreme weather impacting the amount of available natural gas. Inadequate fuel infrastructure, particularly natural gas infrastructure to serve the growing fleet of natural gas-fired power plants is a current and growing reliability risk.

NERC also recommends that in areas impacted by an increasing share of natural-gas-fired generation, transmission planners and operators should identify and report on potential reliability concerns due to natural gas generation with interruptible natural gas transportation and supplies. In wholesale electricity markets, market operators should develop additional rules or incentives to encourage increased fuel security, particularly during winter months.

Fuel Diversity – During the extreme cold, a diverse generation mix with adequate flexible fuel resources and back-up fuel was key to meeting increased electricity demand. All forms of generation contributed to serving load. The outage of the nuclear power station in Massachusetts exemplifies that even the most fuel secure generation resources can be forced out of service when the system needs it most. Accordingly, NERC recommends policymakers and regulators should consider measures promoting fuel diversity and supplemental fuel sources as they evaluate electric system plans, consistent with policy objectives. Additionally, regulators and policymakers should expedite licensing of new transmission and natural gas infrastructure to diversify and distribute risk.

Maintain and Regularly Test Backup Fuel Operability – Generator Owners and Operators of natural gas generation with dual fuel capability should maintain and regularly test operational capabilities and back-up fuel inventories. In the 2014 Polar Vortex, a significant amount of failed oil fuel startups occurred and thus forced units out of service, even those with ample oil backup inventories. A continued and persistent winterization effort should continue to ensure operational readiness. Oil tank replenishment must also be considered.

Expeditious Consideration of Air Permit Waivers – Dual fuel capability increases generation reliability. While oil fuel is an important backup fuel for electric reliability, the use of oil-based fuel is subject to various federal, state, and provincial laws and regulations that can impose limitations when power is most needed for reliability. While oil-fired generation units did not exceed permitted levels during the recent extreme cold period, the situation could become more acute if generators continue to rely on oil during the remaining winter months. When planning for severe weather, temporary air permit waivers may be needed from environmental agencies in advance of extreme winter weather to ensure operational readiness of the resources committed to providing capacity during the winter.

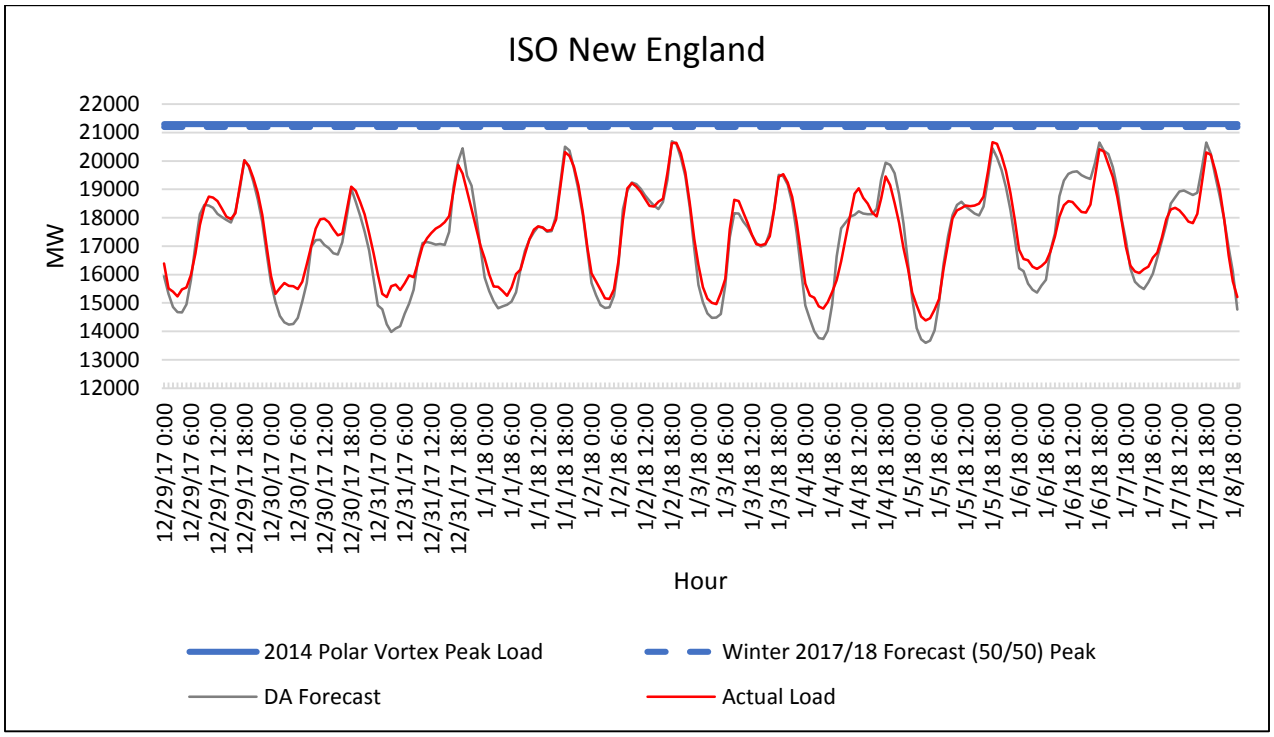
Conclusion

The BPS performed well as a mass of extremely cold air moved into the eastern half of the United States for a sustained period in late 2017 and early 2018. Throughout, NERC's BPSA group operated on elevated status to provide continuous monitoring of the system, working with other NERC departments, Regional Entities, industry and government stakeholders. NERC's analyses of cold weather events across North America, including the 2014 Polar Vortex, along with our ongoing reliability assessment work provide numerous recommendations and lessons learned. This work promotes a learning environment through follow-up and outreach by NERC, Regional Entities, and, most importantly, by the actions of NERC's Registered Entities. We have seen improvement and have also identified areas for further awareness and analysis. We continue to work with our partners at the U.S. Department of Energy and FERC to monitor these events and assure the reliability of North America's bulk power system.

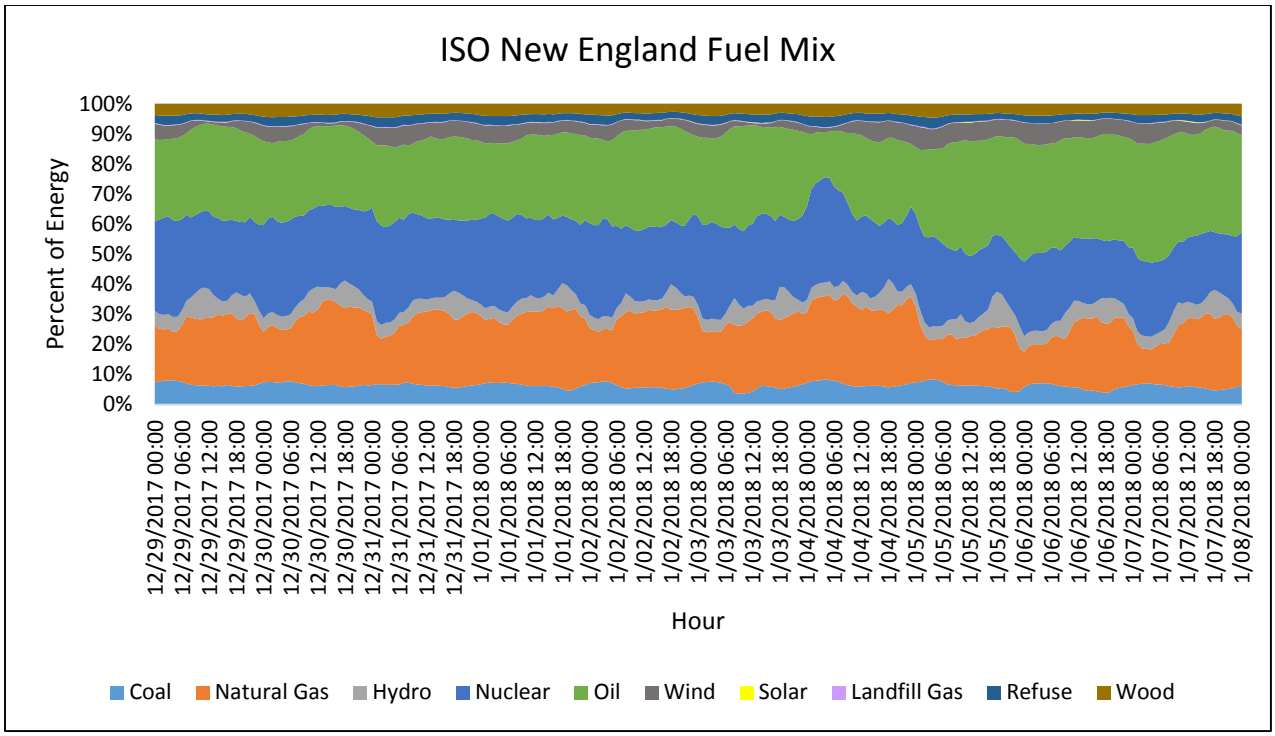
APPENDIX

For each of eight Reliability Coordinator areas during the cold weather period, the following provides additional detail on the performance of the BPS, fuel mix, and measures taken to assure reliability.

ISO New England



Data Sources:
Energy Information Administration US Electric System Operating Data
NERC Polar Vortex Review, 2014
NERC 2017/18 Winter Reliability Assessment



Data Sources:
ISO New England Dispatch Fuel Mix
Power Systems Update: New England grid operations through recent bitter cold weather and preparation for winter storm

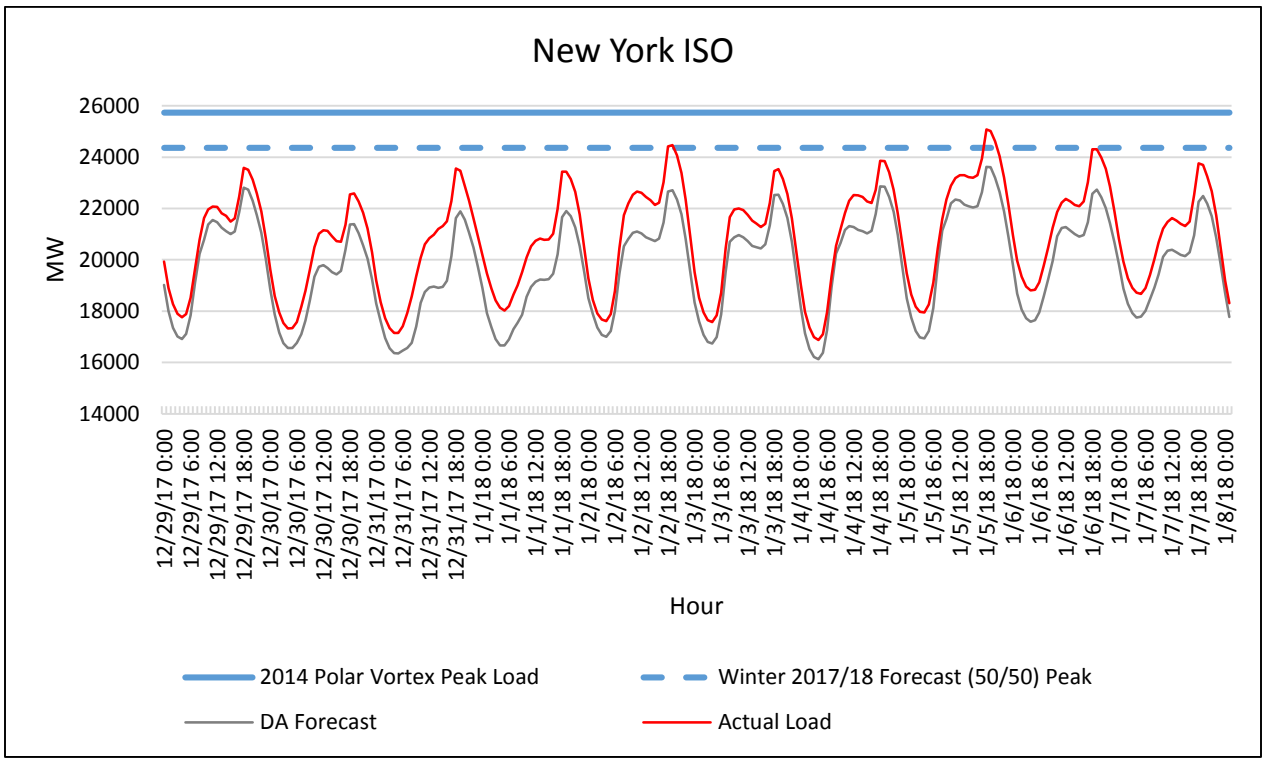
ISO New England observed a peak load of 20,663 MW for hour ending 6:00 PM EST on January 5, at which time they were importing 3,186 MW or 15.4% of their demand. Loads came in between 93.35% and 111.51% of day-ahead hourly forecasts during the period. For comparison, the highest observed load during the 2014 Polar Vortex was 21,300 MW and the forecasted (50/50) peak load for winter 2017/18 is 21,197 MW. ISO-NE did not exceed their seasonal peak forecast or set any peak new load records during the period. ISO-NE implemented their Master/Local Control Center #2 procedures and declared two Cold Weather Watches during this period. These emergency procedures were used as precautionary measures consistent with ISO-NE procedures and practice, and were expected measures given the circumstances.

During the period, ISO NEW England's fuel mix used increasing proportions of fuel oil, and a relatively consistent but higher than normal proportion of coal. Media reporting and initial analysis suggests that this was driven at least in part by economic considerations, as the price of natural gas rose and remained higher than normal due to heavy natural gas consumption for heating and other non-power production uses. Increased use of fuel oil since around December 25 led to onsite oil inventories at many facilities being depleted to uncomfortably low levels;

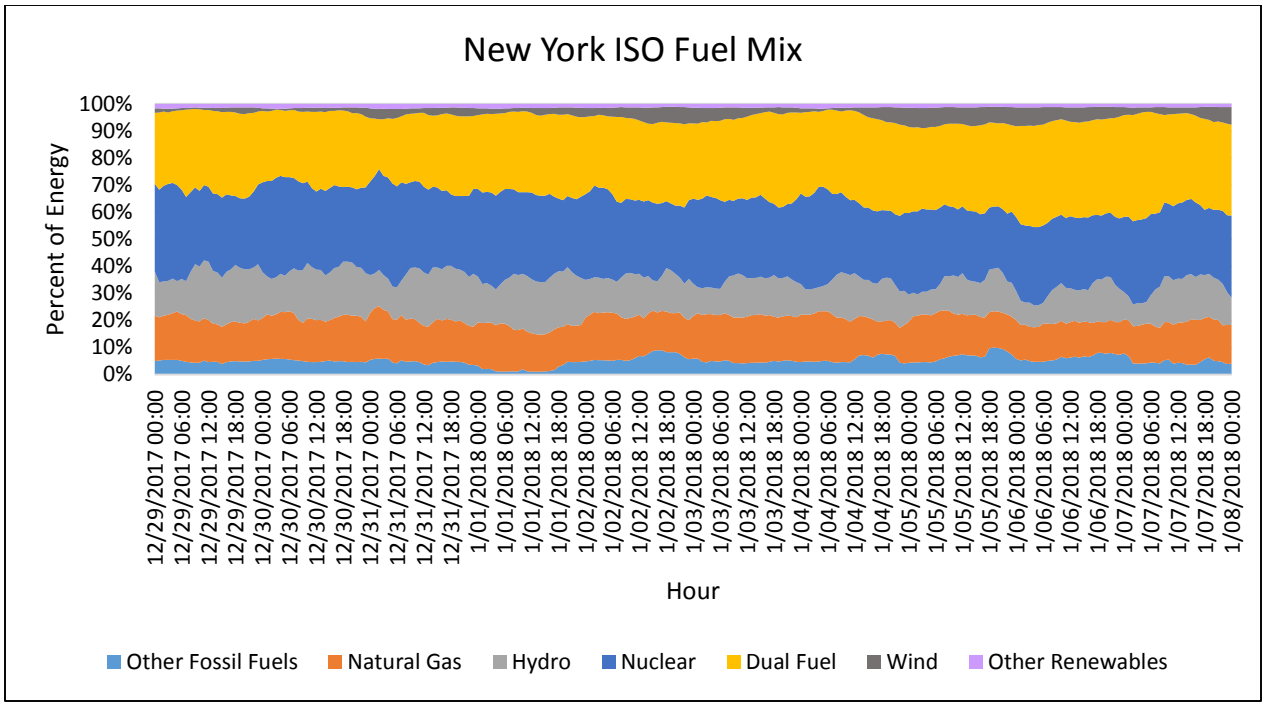
this was compounded by delays in planned resupply deliveries due to Winter Storm Grayson. Other oil-fired generation ran up against emissions limitations.

On Thursday afternoon, January 4, a nuclear generating station in Massachusetts was removed from service by operators subsequent to the loss of a transmission line connecting to the facility. The loss of approximately 685 MW of capacity through late on January 10 exacerbated the challenge of managing fuel availability. ISO-NE delayed the operations of certain resources for later hours or days, operating some facilities out of the economic order of merit in order to ensure adequate generation availability throughout the period.

New York ISO



Data Sources:
Energy Information Administration US Electric System Operating Data
NERC Polar Vortex Review, 2014
NERC 2017/18 Winter Reliability Assessment

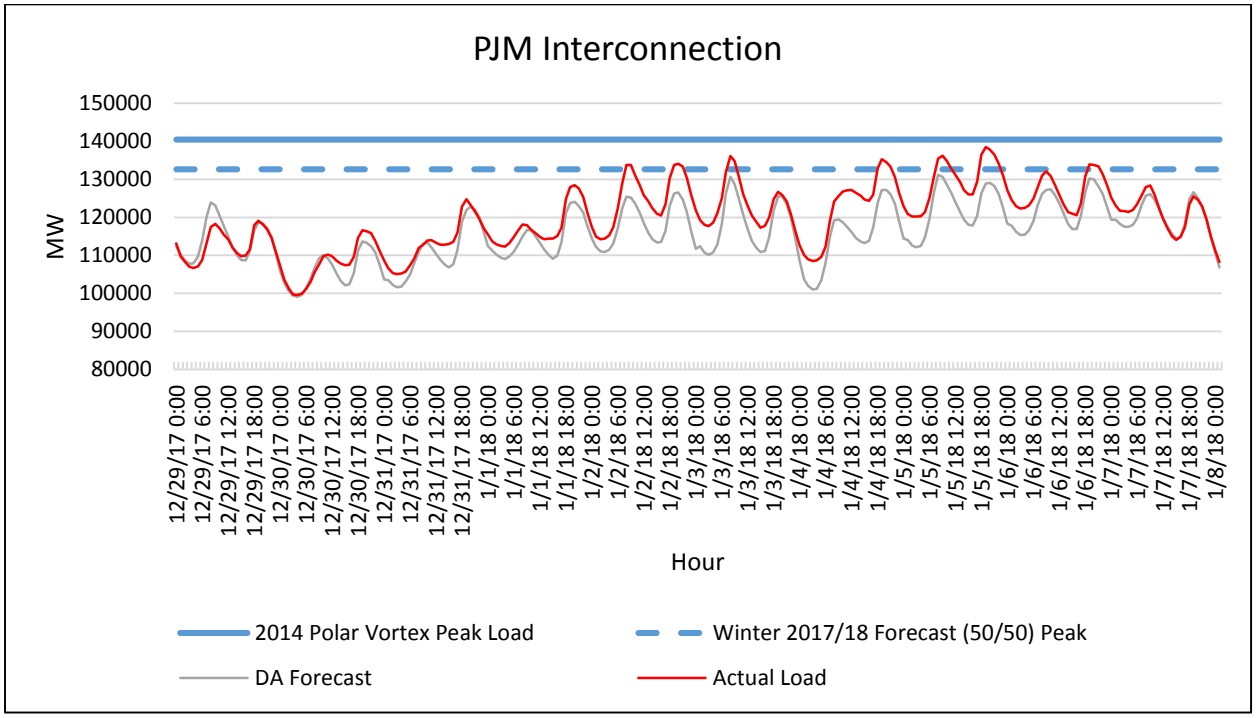


Data Source:
NYISO Data Graphs and Fuel Mix Chart (historical)

New York ISO observed a peak load of 25,081 MW for hour ending 6:00 PM EST on January 5, at which time they were importing 1,414 MW or 5.6% of their demand. Loads came in between 101.49% and 112.52% of day-ahead hourly forecasts during the period. For comparison, the highest observed load during the 2014 Polar Vortex was 25,738 MW and the forecasted (50/50) peak load for winter 2017/18 is 24,365 MW. NYISO exceeded their forecasted seasonal peak by 2.94% but did not set any new record peak loads during this period. NYISO did not implement any emergency procedures directly related to cold weather, high loads, or capacity positions.

New York ISO's fuel mix during the period appears to be within normal ranges for high load winter scenarios, noting a significant and increasing proportion of dual-fuel capable units running throughout the period. One generation facility reported a fuel supply emergency due to delayed rail shipments of coal, but this did not cause an adverse impact to the bulk power system. Initial analysis of generator performance showed good availability and no significant trends of weather-related outages.

PJM Interconnection

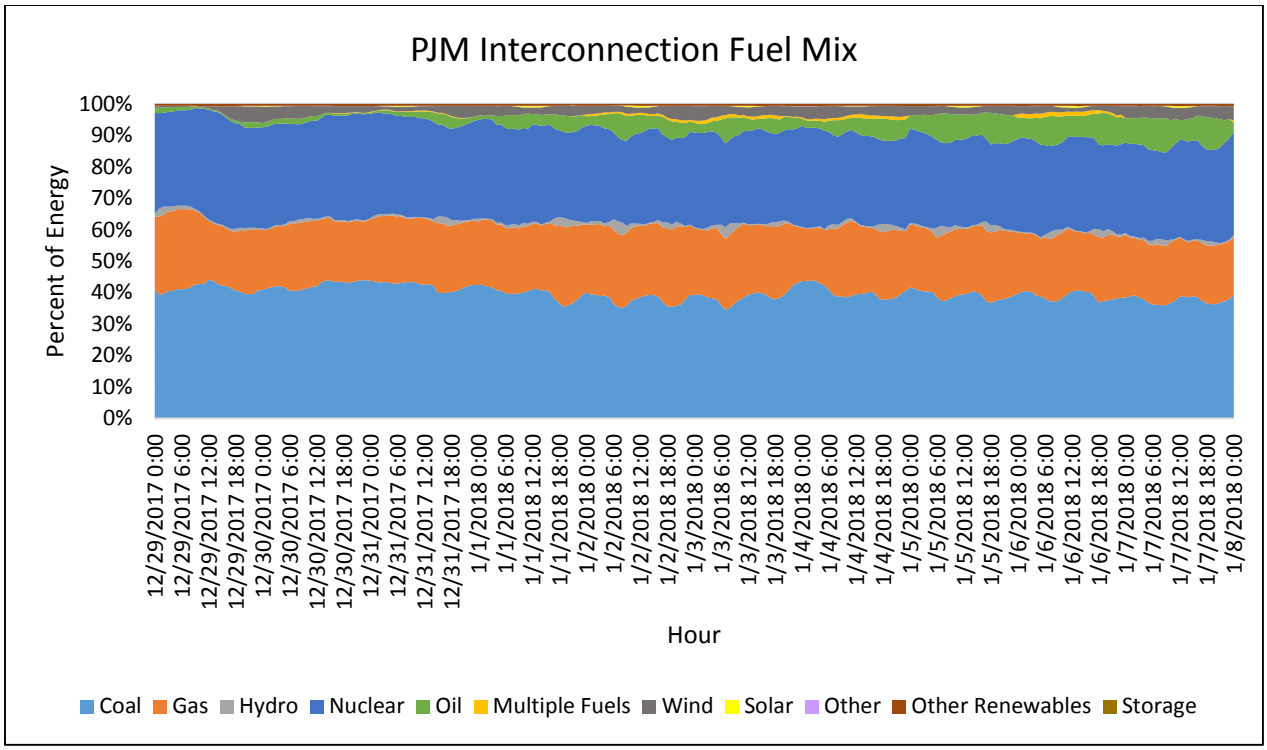


Data Sources:

Energy Information Administration US Electric System Operating Data

NERC Polar Vortex Review, 2014

NERC 2017/18 Winter Reliability Assessment



Data Source:
PJM Data Miner 2 Generation by Fuel Type

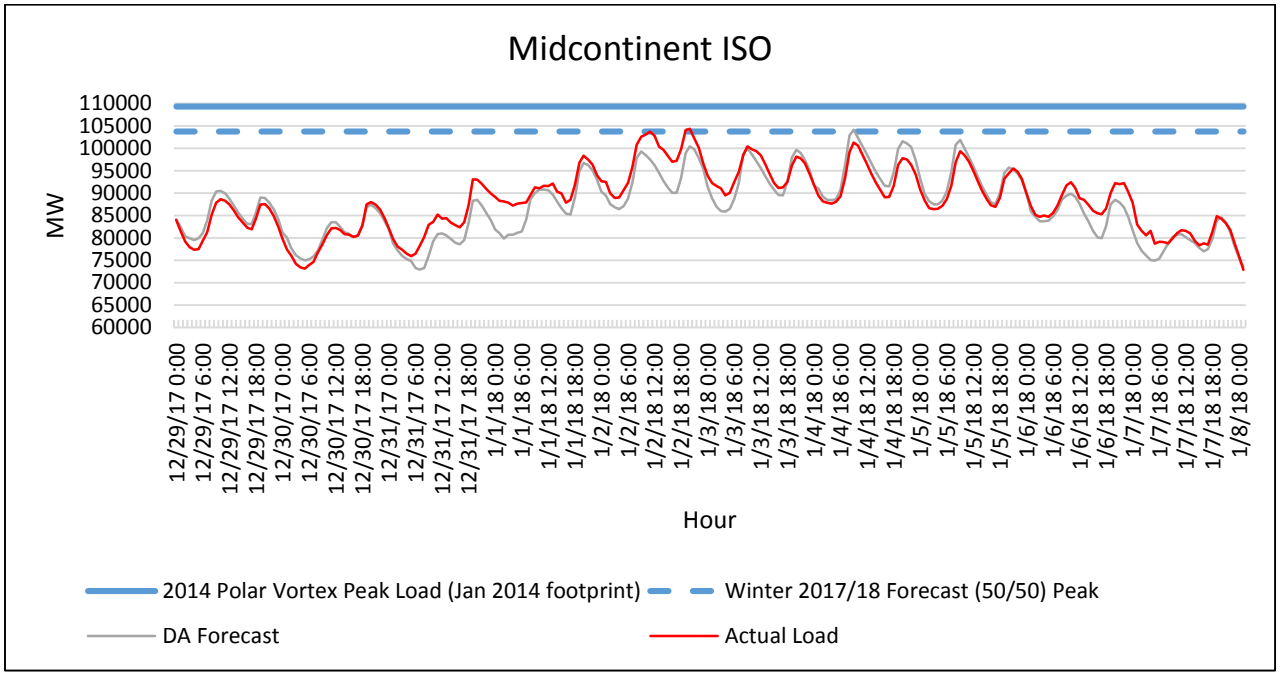
PJM Interconnection observed a peak load of 138,465 MW for hour ending 7:00 PM EST on January 6, at which time they were importing 323 MW or 0.2% of their demand. Loads came in between 95.96% and 110.65% of day-ahead hourly forecasts during the period. For comparison, the highest observed load during the 2014 Polar Vortex was 140,510 MW and the forecasted (50/50) peak load for winter 2017/18 is 132,652 MW. PJM exceeded their forecasted seasonal peak by 4.38% but did not set any new record peak loads during this period. Three of the top ten highest winter peaks occurred during this period, including the fourth highest winter peak.

PJM declared two Cold Weather Alerts during the period, adjusting the affected areas as the deepest cold passed across the RTO footprint. On January 4 and 5, PJM implemented their Heavy Load Voltage Schedule emergency procedures, which involve member companies taking actions on the distribution and sub-transmission systems that will support voltage at extra high voltage (EHV, generally 345kV and above) and increase reactive power reserves on the bulk power system. This emergency procedure is typically implemented during protracted periods of high loads driven by extreme heat or cold, and while its use is not a signal of particular concern it does indicate elevated stress on the transmission system and reactive power resources.

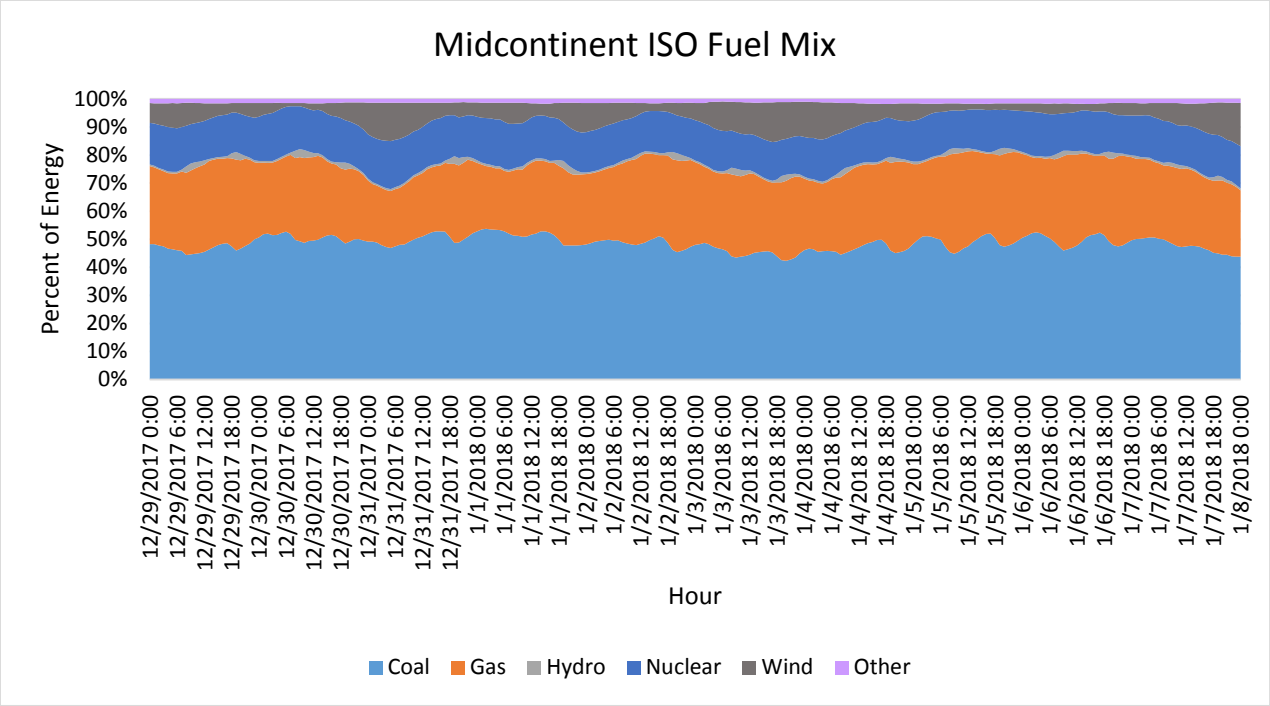
PJM Interconnection's fuel mix during the period appears to be within normal ranges for high load winter scenarios. The proportion of fuel oil used increased throughout the period but

remained a fairly small fraction of overall generation. Initial analysis of generator performance showed good availability and no significant trends of weather-related outages.

Midcontinent ISO



Data Sources:
Energy Information Administration US Electric System Operating Data
NERC Polar Vortex Review, 2014
NERC 2017/18 Winter Reliability Assessment



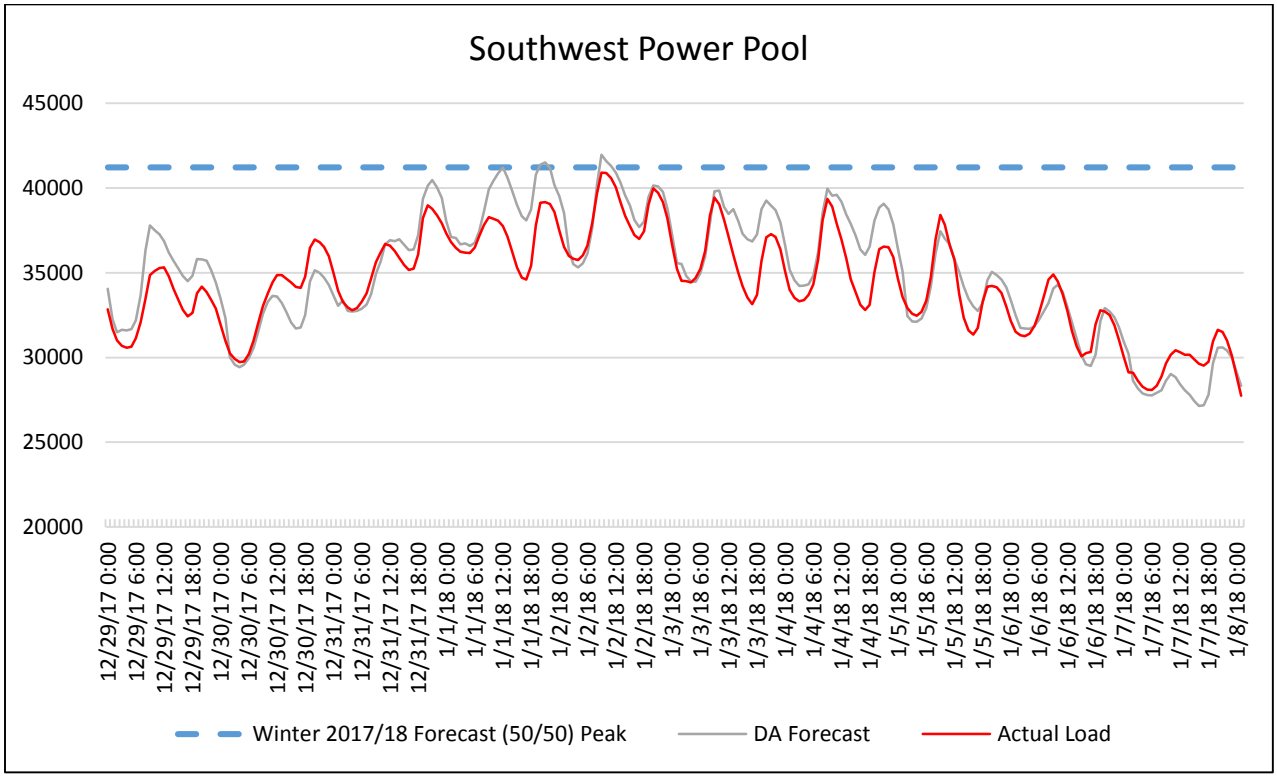
Data Source: MISO Energy Market Reports – Sub-regional Generation Fuel Mix

Midcontinent ISO (MISO) observed a peak load of 104,367 MW for hour ending 7:00 PM CST on January 3, at which time they were exporting 2,930 MW. Loads came in between 94.20% and 110.38% of day-ahead hourly forecasts during the period. For comparison, the forecasted (50/50) peak load for winter 2017/18 is 103,731 MW. During the 2014 Polar Vortex the highest observed load was 109,307 MW, but that figure included approximately 5,000 MW of peak demand (from WAPA Upper Great Plains, Basin Electric Power Cooperative, and Heartland Consumers Power District) that transitioned out of from MISO to SPP in 2015. MISO exceeded their forecasted seasonal peak by 0.61% but did not set any new record peak loads during this period. Duke Energy Indiana set a new all-time winter peak record of 7,281 MW for hour ending 9:00 AM CST on January 2.

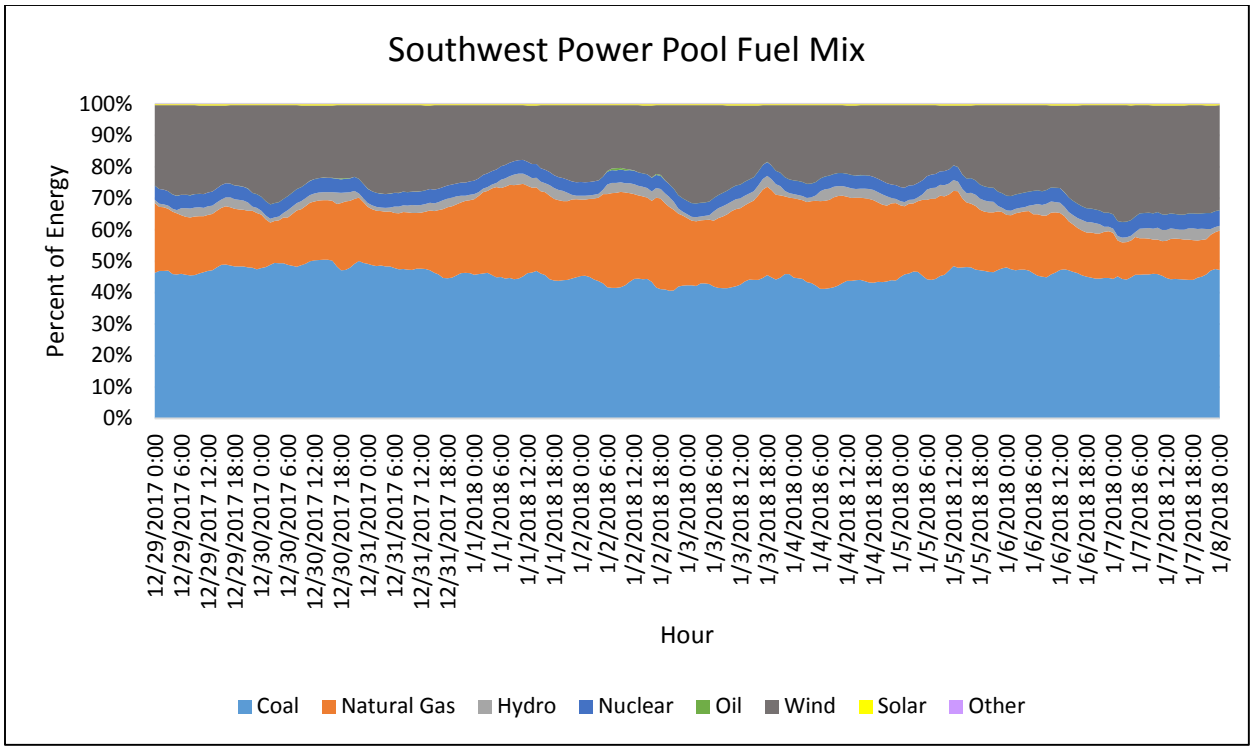
MISO implemented their Conservative Operations procedures and declared a Cold Weather Alert for varying parts of the ISO footprint during this period. These emergency procedures were used as precautionary measures consistent with MISO procedures and practice, and were expected measures given the circumstances.

Midcontinent ISO's fuel mix during the period appears to be within normal ranges for high load winter scenarios. Initial analysis of generator performance showed good availability and no significant trends of weather-related outages.

Southwest Power Pool



Data Sources:
Energy Information Administration US Electric System Operating Data
SPP Integrated Marketplace MTLF vs. Actual (to backfill missing EIA-930 data)
NERC Polar Vortex Review, 2014
NERC 2017/18 Winter Reliability Assessment



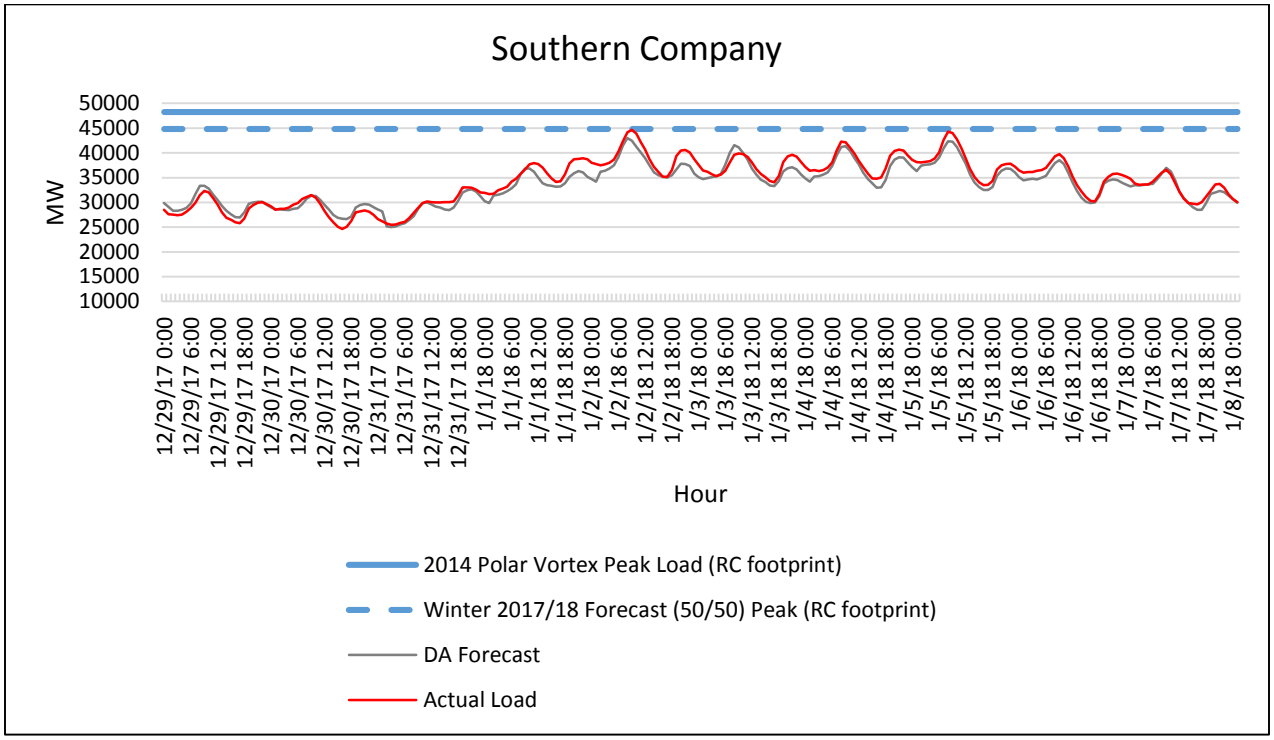
Data Source:
SPP Integrated Marketplace Hourly Generation Capacity by Fuel Type

Southwest Power Pool (SPP) observed a peak load of 40,920 MW for hour ending 7:00 PM CST on January 2, at which time they were exporting 860 MW. Loads came in between 89.95% and 121.07% of day-ahead hourly forecasts during the period. During the 2014 Polar Vortex the highest observed load was 36,602 MW, but that figure did not include approximately 5,000 MW of peak demand (from WAPA Upper Great Plains, Basin Electric Power Cooperative, and Heartland Consumers Power District) that transitioned from MISO into SPP in 2015. SPP did not exceed any seasonal forecast or record peak loads during this period.

SPP declared a Cold Weather Alert for the RTO footprint during this period but did not implement any emergency procedures directly related to high loads or capacity positions.

Southwest Power Pool's fuel mix during the period appears to be within normal ranges for high load winter scenarios. Initial analysis of generator performance showed good availability and no significant trends of weather-related outages.

Southern Company and Southeastern Reliability Coordinator



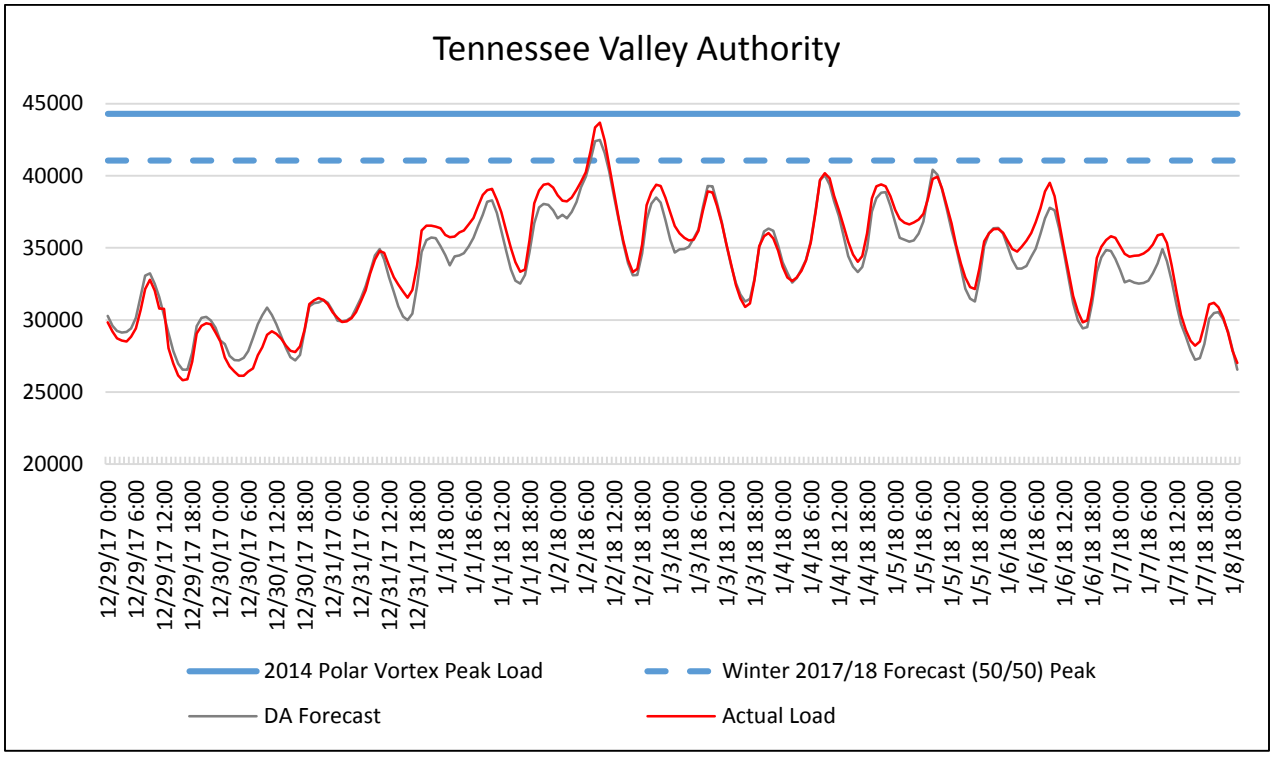
Data Sources:
Energy Information Administration US Electric System Operating Data
NERC Polar Vortex Review, 2014
NERC 2017/18 Winter Reliability Assessment

Southern Company (the Balancing Authority Area, not the larger Southeastern Reliability Coordinator footprint) observed a peak load of 44,656 MW for hour ending 9:00 AM EST on January 2, at which time they were importing 2,504 MW or 5.6% of their demand. Loads came in between 92.30% and 110.55% of day-ahead hourly forecasts during the period. For comparison, for the larger Southeastern Reliability Coordinator footprint (which includes the loads from PowerSouth Energy Cooperative, Alabama Electric Cooperative, and Southeastern Power Administration Balancing Authority Areas) the highest load observed during the 2014 Polar Vortex was 48,279 MW, and the forecasted (50/50) peak load for winter 2017/18 is 44,805 MW.

Southeastern RC implemented their Conservative Operations Watch emergency procedures as precautionary measures consistent with internal procedures and past practice. This was an expected measure given the circumstances. Southeastern RC declared an Energy Emergency Alert 1 (EEA-1) for the Alabama Electric Cooperative Balancing Authority (AEC BA) for 6½ hours on the morning of January 2; an EEA-1 is an emergency procedure used to communicate between operators that for a Balancing Authority, all available generation is committed to serve

load and meet operating reserve requirements, and that BA is concerned about sustaining adequate contingency reserves in the near future. No further emergency procedures were required to maintain adequate generation resources.

Tennessee Valley Authority



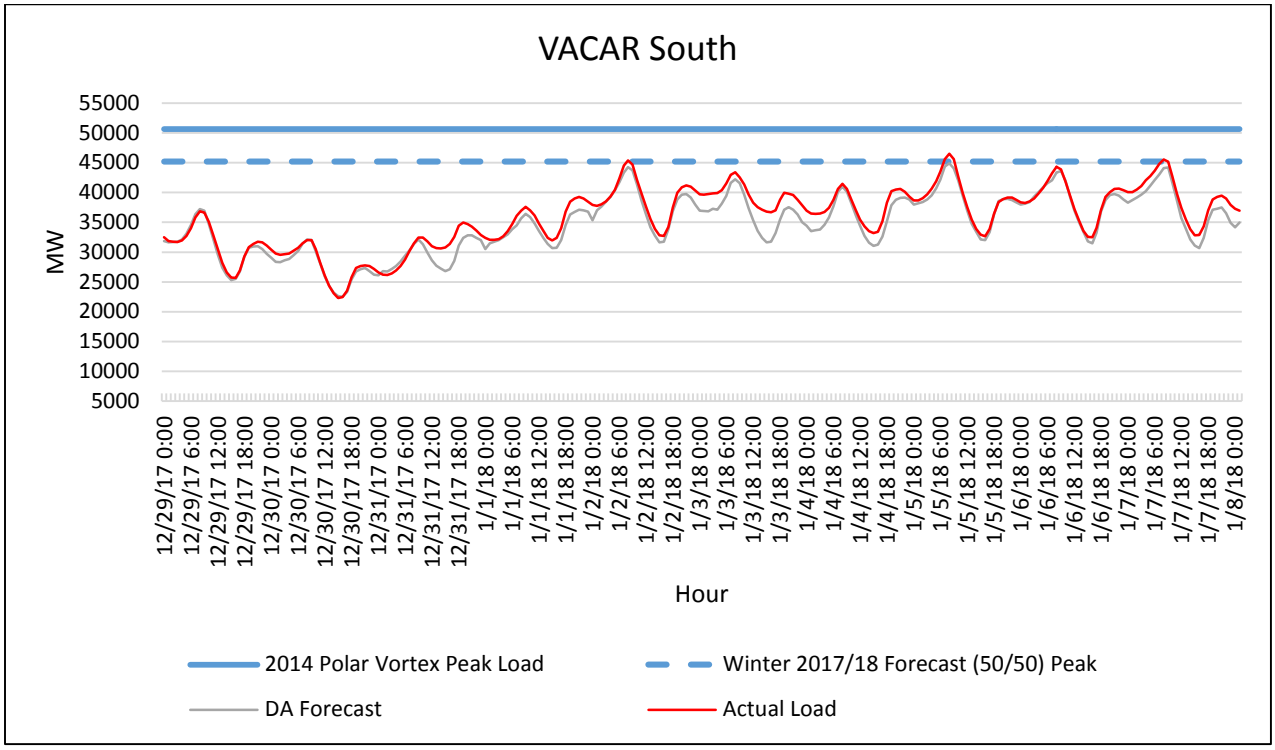
Data Sources:
Energy Information Administration US Electric System Operating Data
NERC Polar Vortex Review, 2014
NERC 2017/18 Winter Reliability Assessment

Tennessee Valley Authority (TVA) (the larger Reliability Coordinator footprint, including TVA, Louisville Gas & Electric/Kentucky Utilities, and Associated Electric Cooperative Balancing Authority Areas) observed a peak load of 43,696 MW for hour ending 9:00 AM CST on January 2, at which time they were importing 2,869 MW or 6.57% of their demand. Loads came in between 92.67% and 106.48% of day-ahead hourly forecasts during the period. For comparison, the highest observed load during the 2014 Polar Vortex was 44,285 MW and the forecasted (50/50) peak load for winter 2017/18 is 41,051 MW. TVA exceeded their forecasted seasonal peak by 6.44% but did not set any new record peak loads during this period.

TVA implemented their Conservative Operations Watch emergency procedures for the Reliability Coordinator footprint as a precautionary measure consistent with internal

procedures and past practice. As a tool to manage heavy loads, TVA issued a Power Supply Alert and implemented selected initial measures of its Emergency Load Curtailment Plan emergency procedure. This included making public appeals for voluntary load reductions for all customers in the RC footprint, from the evening of January 1 through January 5. TVA RC declared an Energy Emergency Alert 1 (EEA-1) for the TVA BA footprint for seven hours on the morning of January 2.

VACAR South Reliability Coordinator



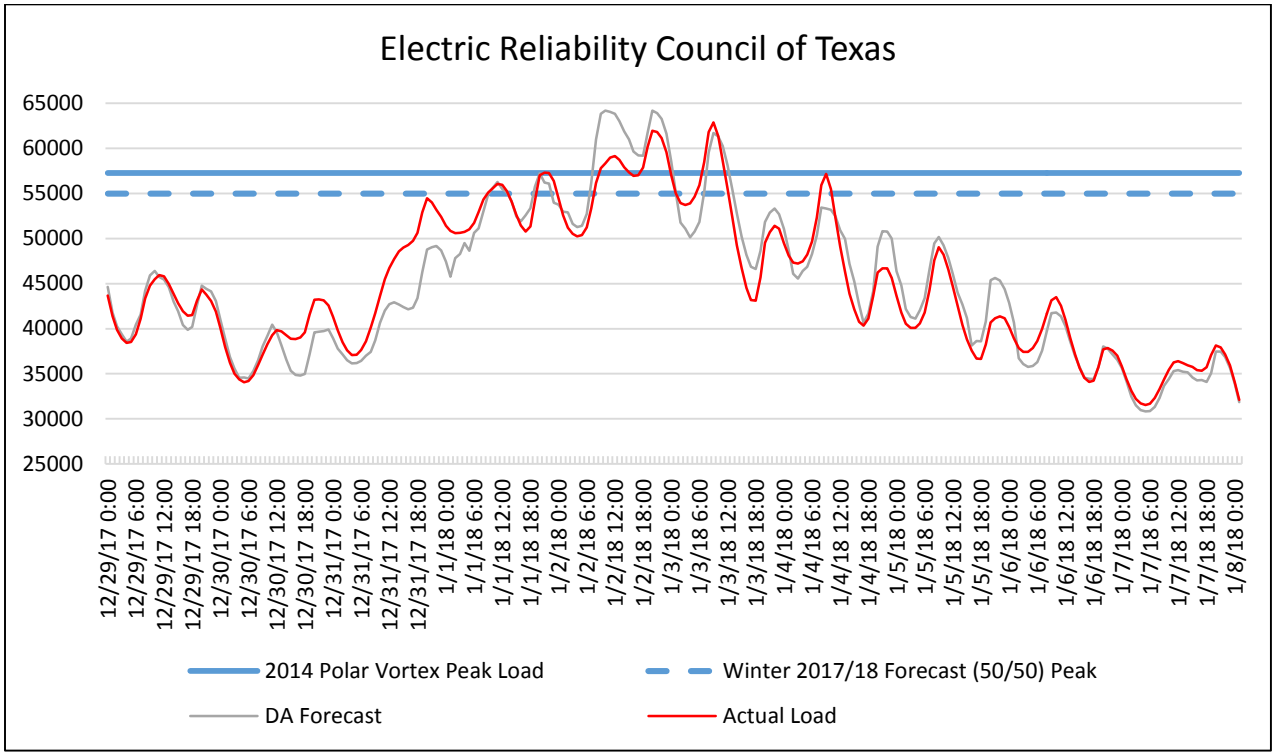
Data Sources:
Energy Information Administration US Electric System Operating Data
NERC Polar Vortex Review, 2014
NERC 2017/18 Winter Reliability Assessment

VACAR South Reliability Coordinator footprint (including Duke Energy Carolinas, Duke Energy Progress, South Carolina Electric & Gas Company, and South Carolina Public Service Authority (Santee Cooper) Balancing Authority Areas) observed a peak load of 46,495 MW for hour ending 8:00 AM EST on January 5, at which time they were importing 2,039 MW or 4.39% of their demand. Loads came in between 97.24% and 116.26% of day-ahead hourly forecasts during the period. For comparison, the highest observed load during the 2014 Polar Vortex was 50,659 MW and the forecasted (50/50) peak load for winter 2017/18 is 45,189 MW. VACAR South exceeded their forecasted seasonal peak by 2.89% but did not set any new record peak

loads during this period. Duke Energy Carolinas set a new all-time peak load (21,163 MW for hour ending 8:00 AM on January 5) and South Carolina Electric & Gas set a new all-time electricity usage record (103,700 MWh on January 3).

VACAR South RC implemented their Conservative Operations Watch emergency procedures as precautionary measures consistent with internal procedures and past practice. This was an expected measure given the circumstances. The most significant stress to the bulk power system was on the morning of January 2, which saw EEA-1 declarations for the Duke Energy Progress (CPLE and CPLW), Duke Energy Carolinas (DUK), Santee Cooper (SC), and South Carolina Electric & Gas (SCEG) BAs. A 5% voltage reduction was implemented across the Duke Energy Progress Balancing Authorities to reduce consumption through the morning peak load period. Concurrent with the voltage reduction VACAR South declared an Energy Emergency Alert 2 (EEA-2) for Duke Energy Progress, indicating that the Balancing Authorities were no longer able to provide its expected energy requirements and has implemented its Operating Plan(s) to mitigate Emergencies, but is still able to maintain minimum Contingency Reserve requirements in real time. South Carolina Electric & Gas made public appeals for voluntary load reduction on the morning of January 2, lasting until January 7. VACAR South also declared EEA-1s for the Santee Cooper BA over morning peak hours on January 4, 5, and 6. January 7 was also a challenging morning, seeing EEA-1 declarations for Duke Energy Progress, Duke Energy Carolinas, and Santee Cooper BAs, with Duke Energy Progress and Santee Cooper being elevated to EEA-2 for a period of time.

Electric Reliability Council of Texas



Data Sources:
Energy Information Administration US Electric System Operating Data
NERC Polar Vortex Review, 2014
NERC 2017/18 Winter Reliability Assessment

Electric Reliability Council of Texas (ERCOT) observed a peak load of 62,855 MW for hour ending 8:00 AM CST on January 3, at which time they were importing 73 MW across the DC ties, or 0.12% of their demand. Loads came in between 89.71% and 117.56% of day-ahead hourly forecasts during the period. For comparison, the highest observed load during the 2014 Polar Vortex was 57,277 MW and the forecasted (50/50) peak load for winter 2017/18 is 55,033 MW. ERCOT exceeded their forecasted seasonal peak by 14.26%, and set a new record winter peak, exceeding the previous peak of 59,650 MW (set hour ending 9:00 AM on January 6, 2017) during several hours on January 2 and 3. CPS Energy also set a new all-time peak demand record of 4,300 MW for hour ending 8:00 AM CST on January 3.

ERCOT issued an Operating Condition Notice for potentially extreme cold weather from January 1-4, consistent with ISO protocols and practice. This was an expected measure given the circumstances. A number of units tripped during the period, but there was no adverse impact to reliability as available reserves remained well above required levels. AEP Texas issued public appeals for energy conservation for customers impacted by distribution system outages in the Laredo and Rio Grande Valley areas, to help relieve challenges due to cold load pickup during distribution outage restoration. This was not related to any BPS conditions, but did receive

significant regional media coverage as some of the customer outages were protracted or multiple outages.