



Cold Weather Operations

December 24, 2017 – January 8, 2018

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EXECUTIVE VICE PRESIDENT AND CHIEF OPERATING OFFICER



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COLD WEATHER CONDITIONS

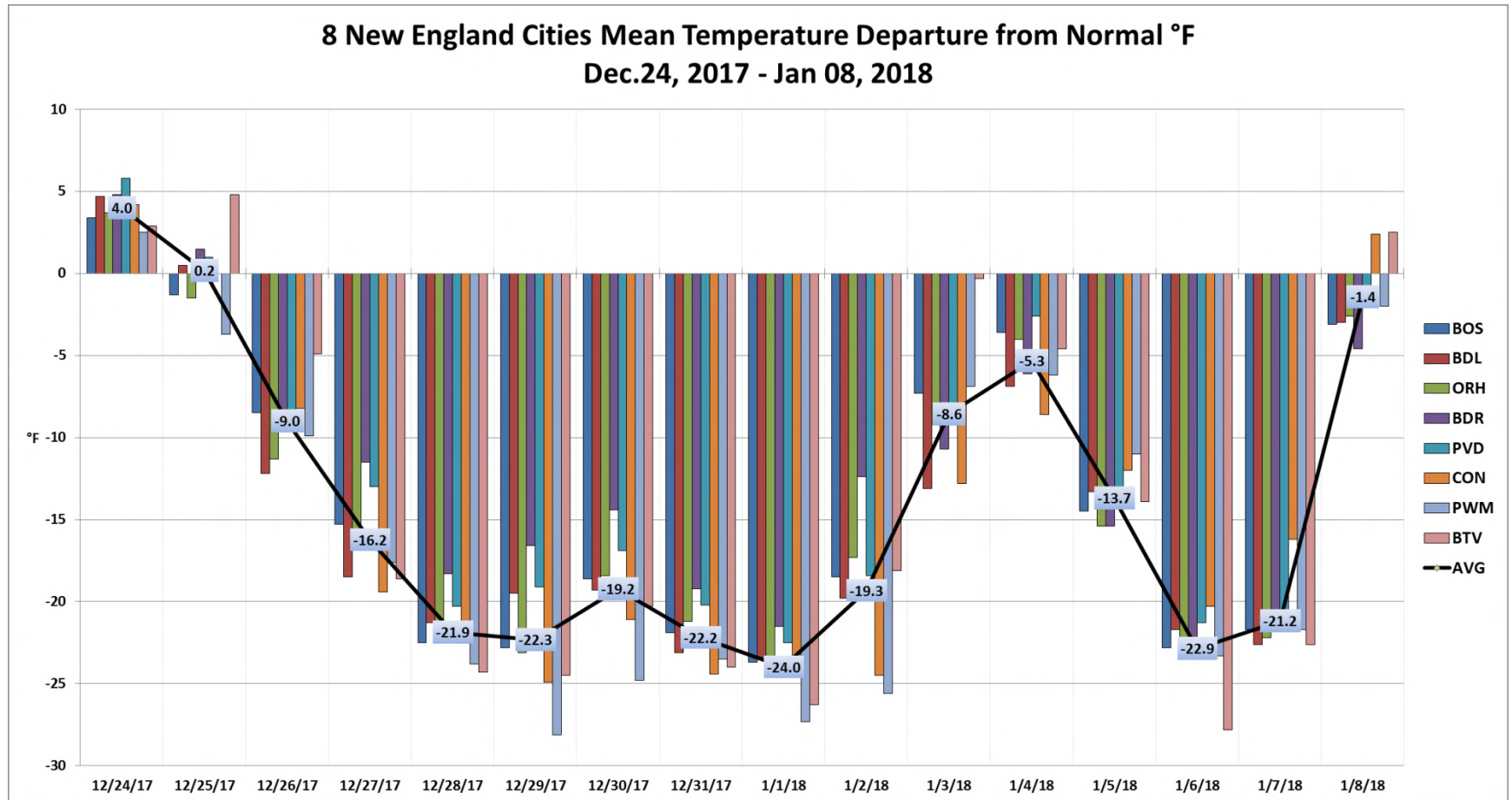


Arctic Outbreak 2017-18

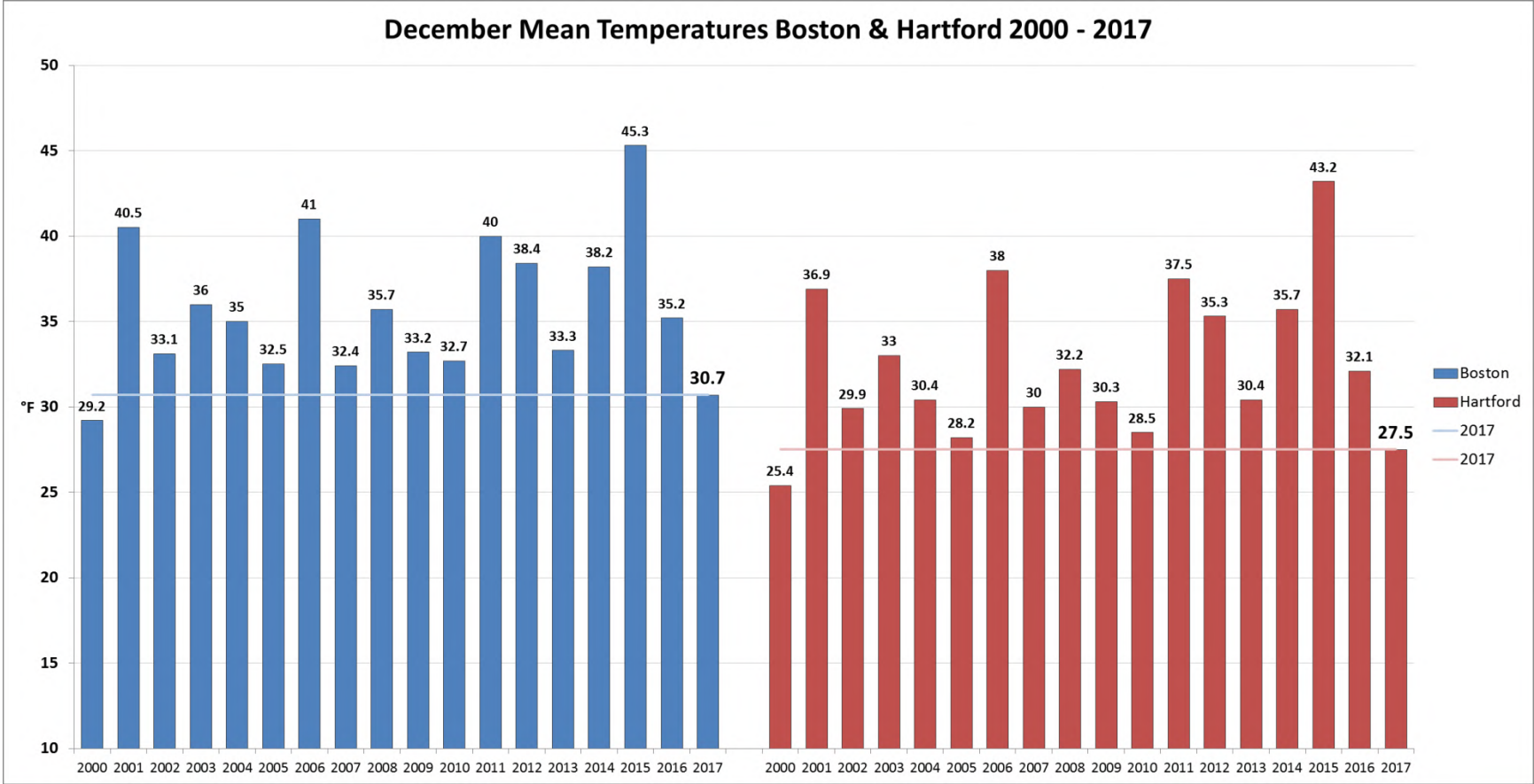
- New England was gripped by a cold weather stretch for an extended duration between December 25 and January 8
- All major cities in New England had average temperatures below normal for at least 13 consecutive days, of which 10 days averaged more than 10°F below normal
- In Boston, for example, an Arctic air-mass brought one of the most extreme cold waves in 100 years with above average winds causing extended periods of frigid wind chill temperatures.



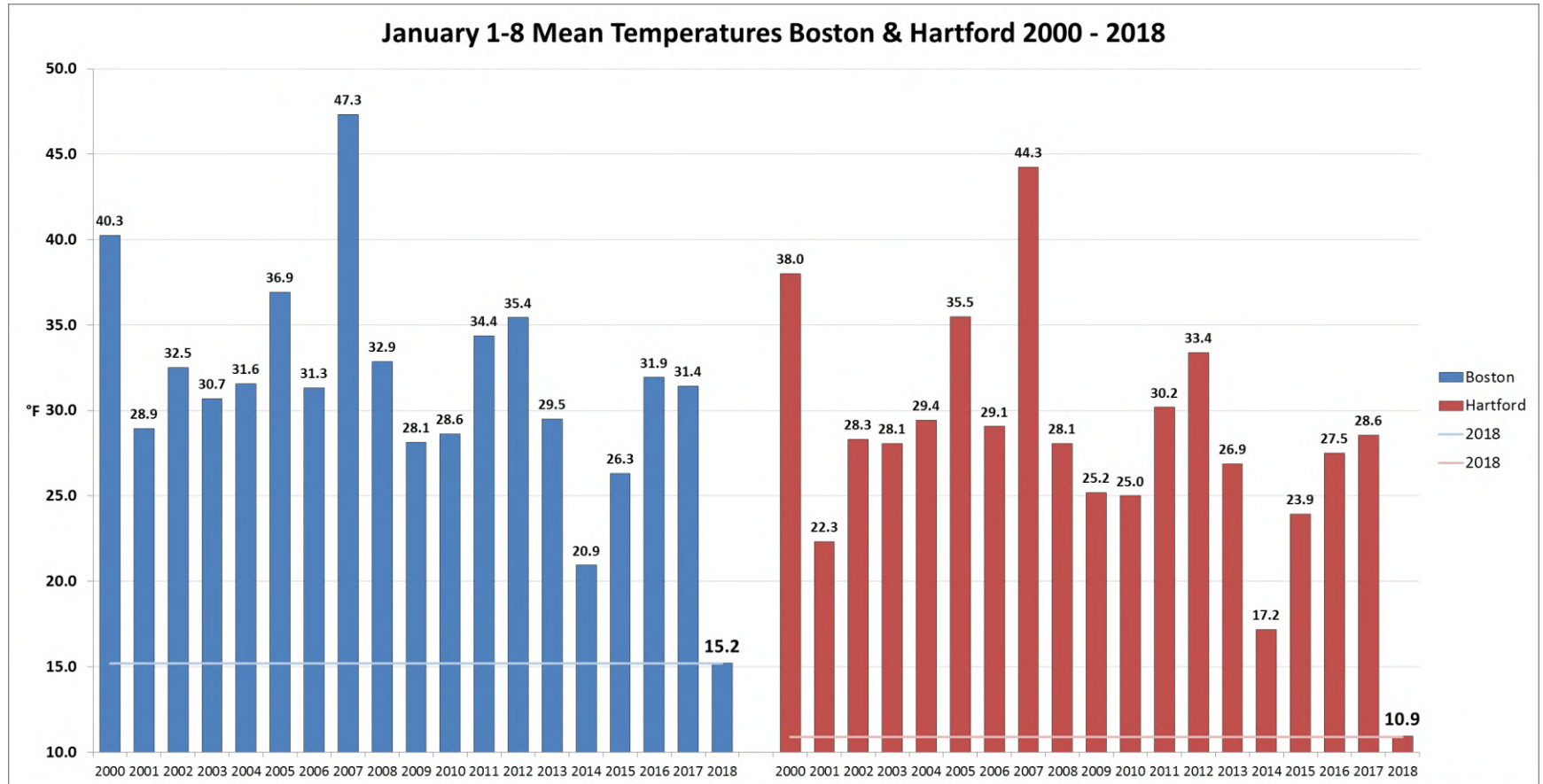
Mean Temperatures Depart from Normal



Coldest December Mean Temps since at least 2000

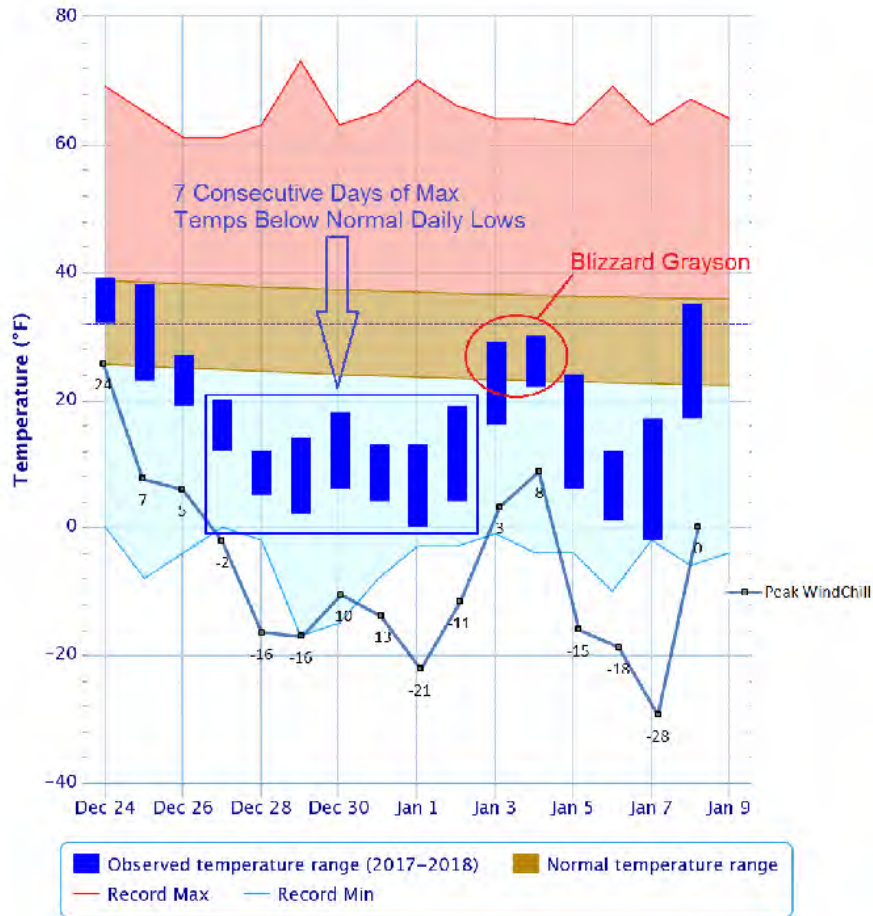


Coldest January 1-8 since at least 2000



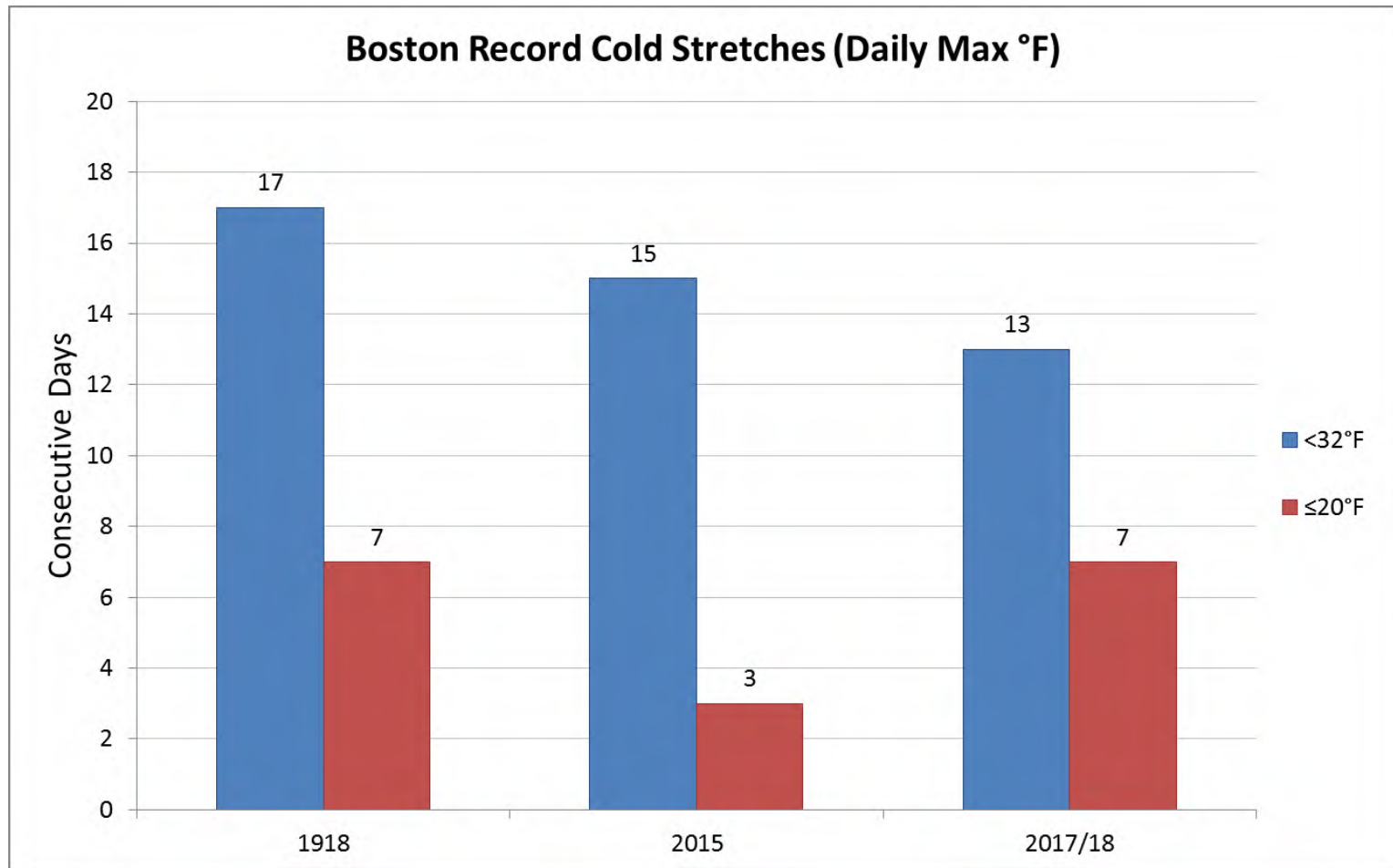
Arctic Outbreak 2017-18 Boston Temperatures

Daily Temperature Data - Boston, MA
December 24, 2017 - January 08, 2018



- Record length of frigid temperatures occurred in Boston from 12/27/17-1/7/18, separated by a Blizzard on 1/4/18 which slightly moderated temperature
- 7 consecutive days with daily maximum temperature below the normal low for the date
- 15 consecutive days with minimum temperature below normal
- Winds were frequently stronger than average during the outbreak, which caused extended periods of frigid wind chill temperatures

Boston: Coldest Stretch In 100 Years



Historical Consecutive Cold Days in Boston
Coldest Stretch (Daily Max ≤20°F) In 100 Years Dating Back To 1918

FUEL MIX

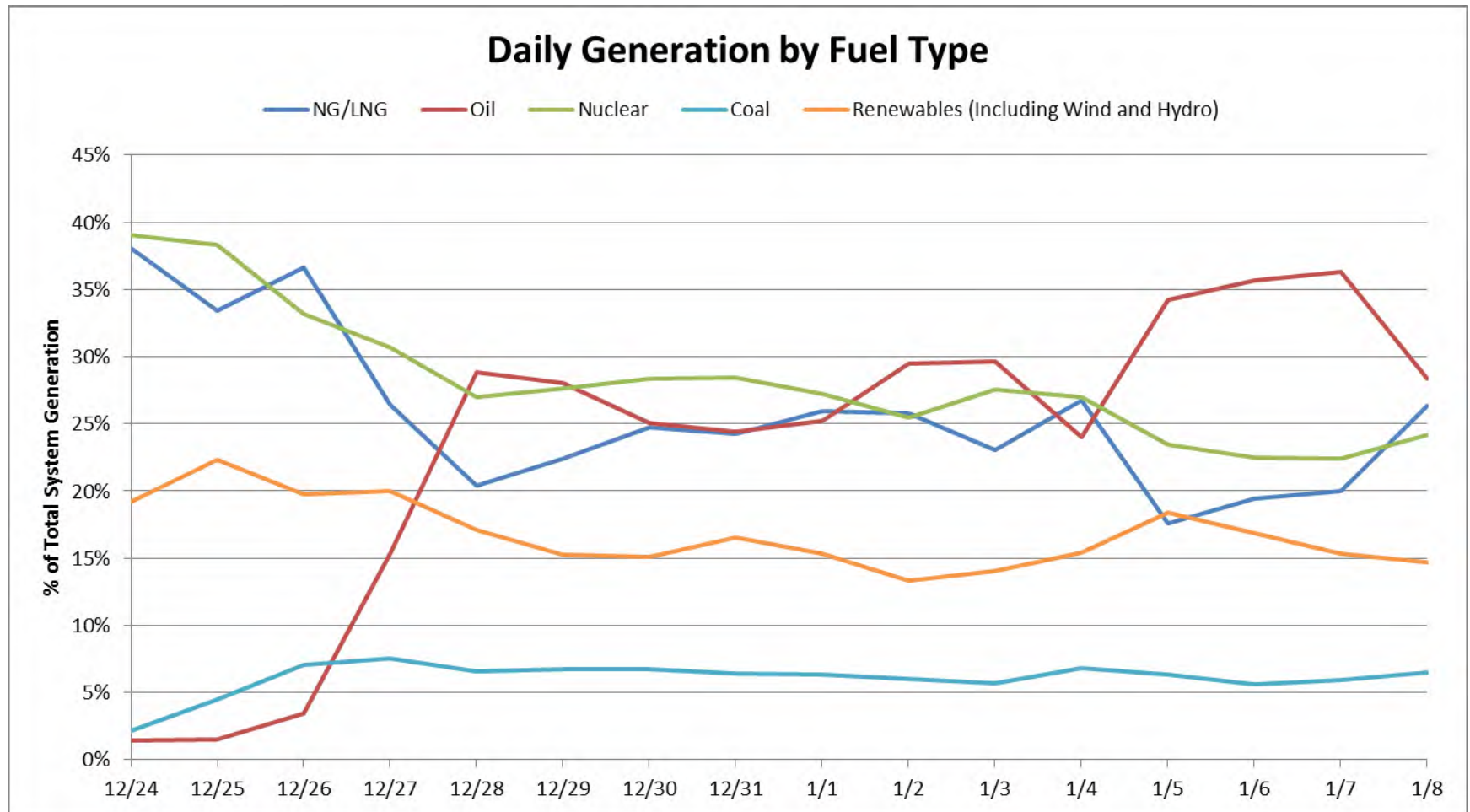


New England Fuel Mixture

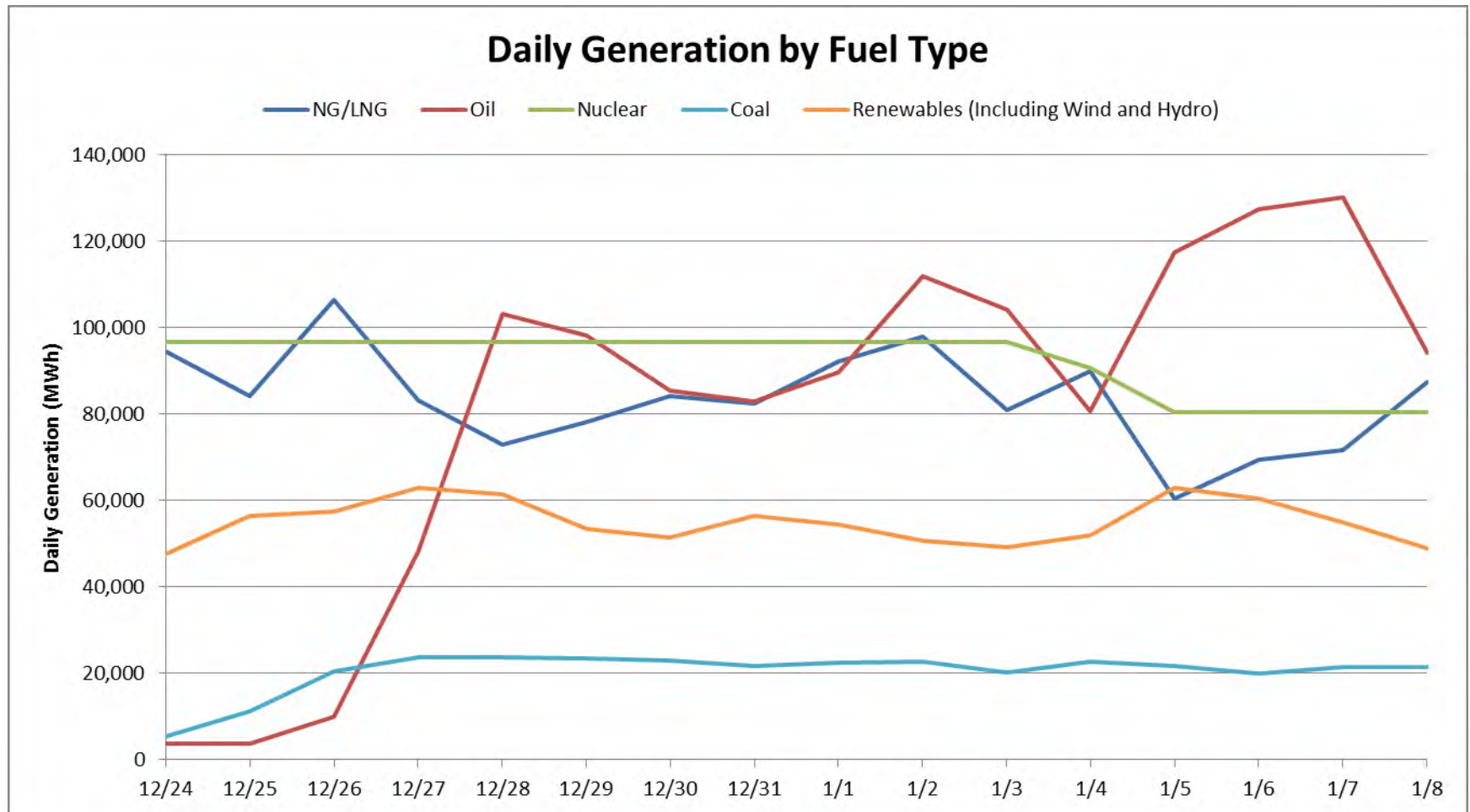
- Overall, there was significantly higher than normal use of oil
 - Coal use also increased over normal use
- Gas and Oil fuel price inversion led to oil being in economic merit and base loaded
- As gas became uneconomic, the entire season's oil supply rapidly depleted



Daily Generation by Fuel Type (Percent of total)

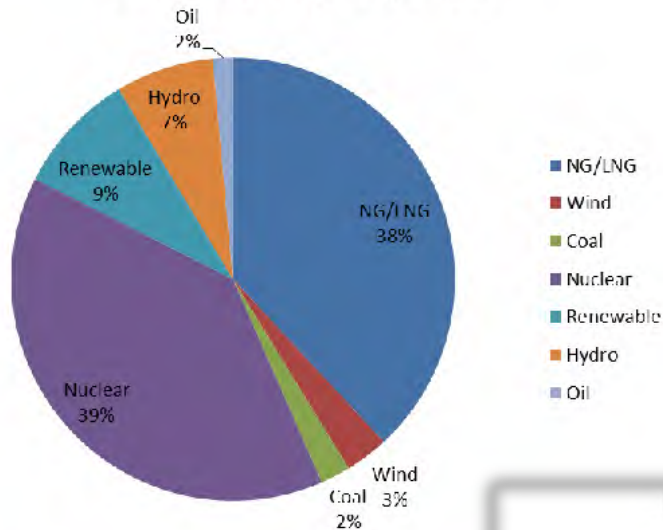


Daily Generation by Fuel Type (MWh)

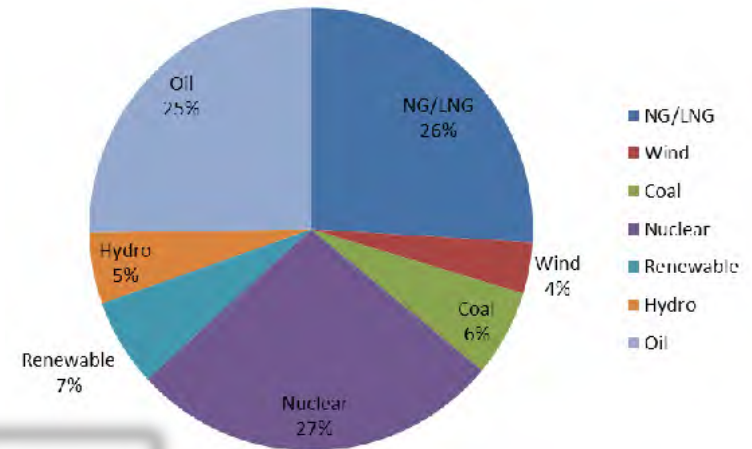


Shifting Generation Mix Before and During the Cold Snap

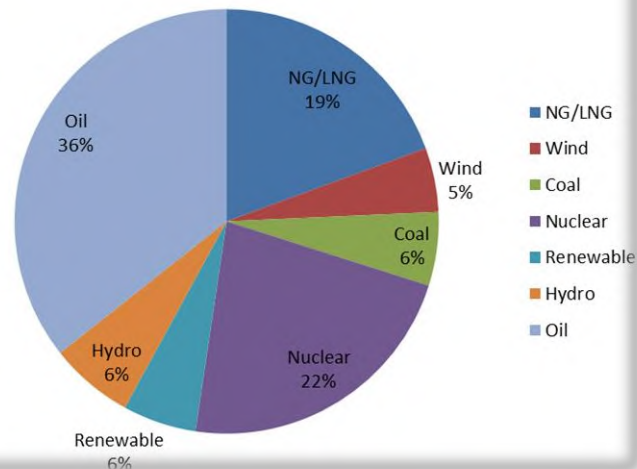
Fuel Diversity - 12/24/17



Fuel Diversity - 1/1/18



Fuel Diversity - 1/6/18



COLD WEATHER OIL USAGE

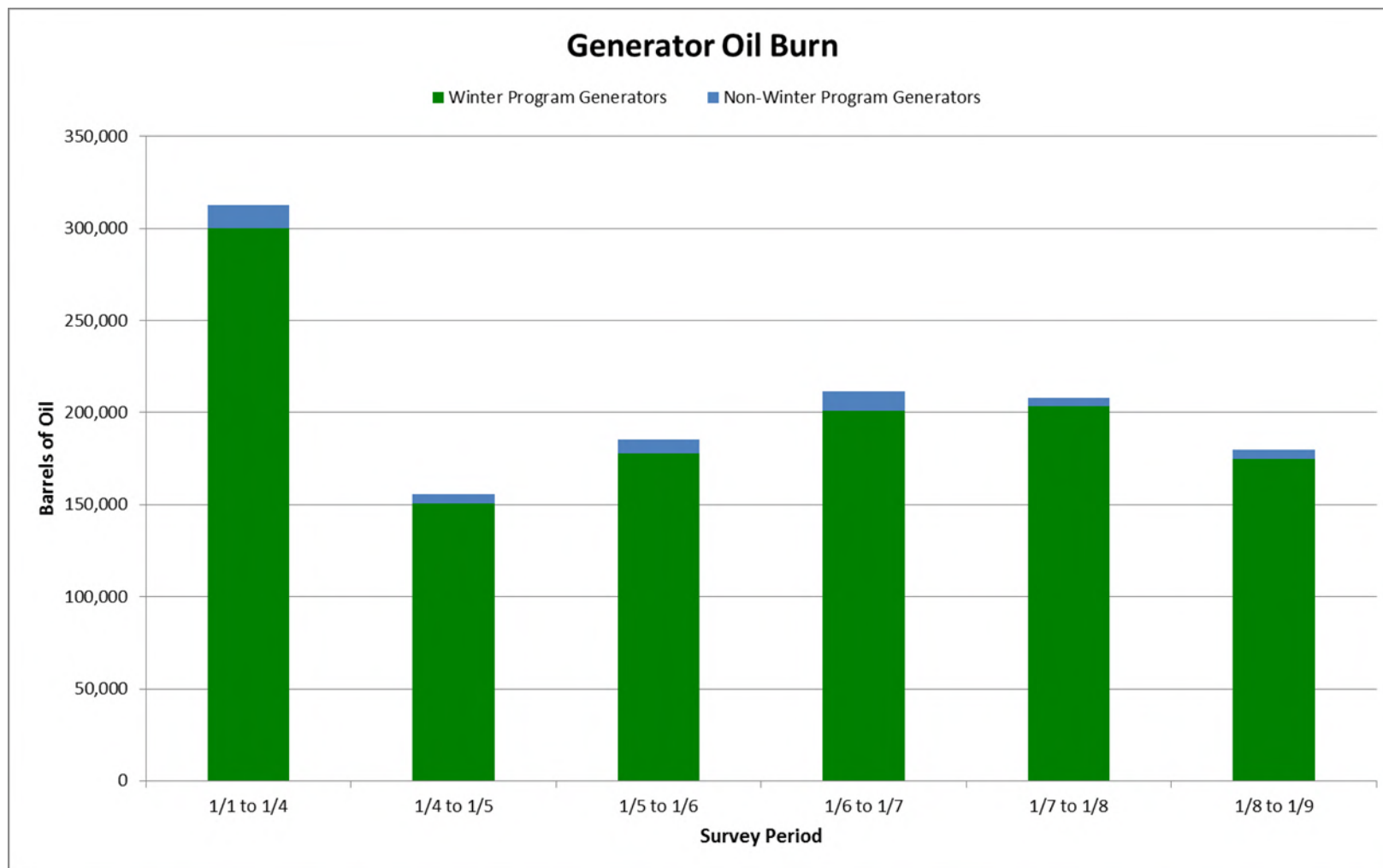


Winter Reliability Program vs Actual Oil Burn

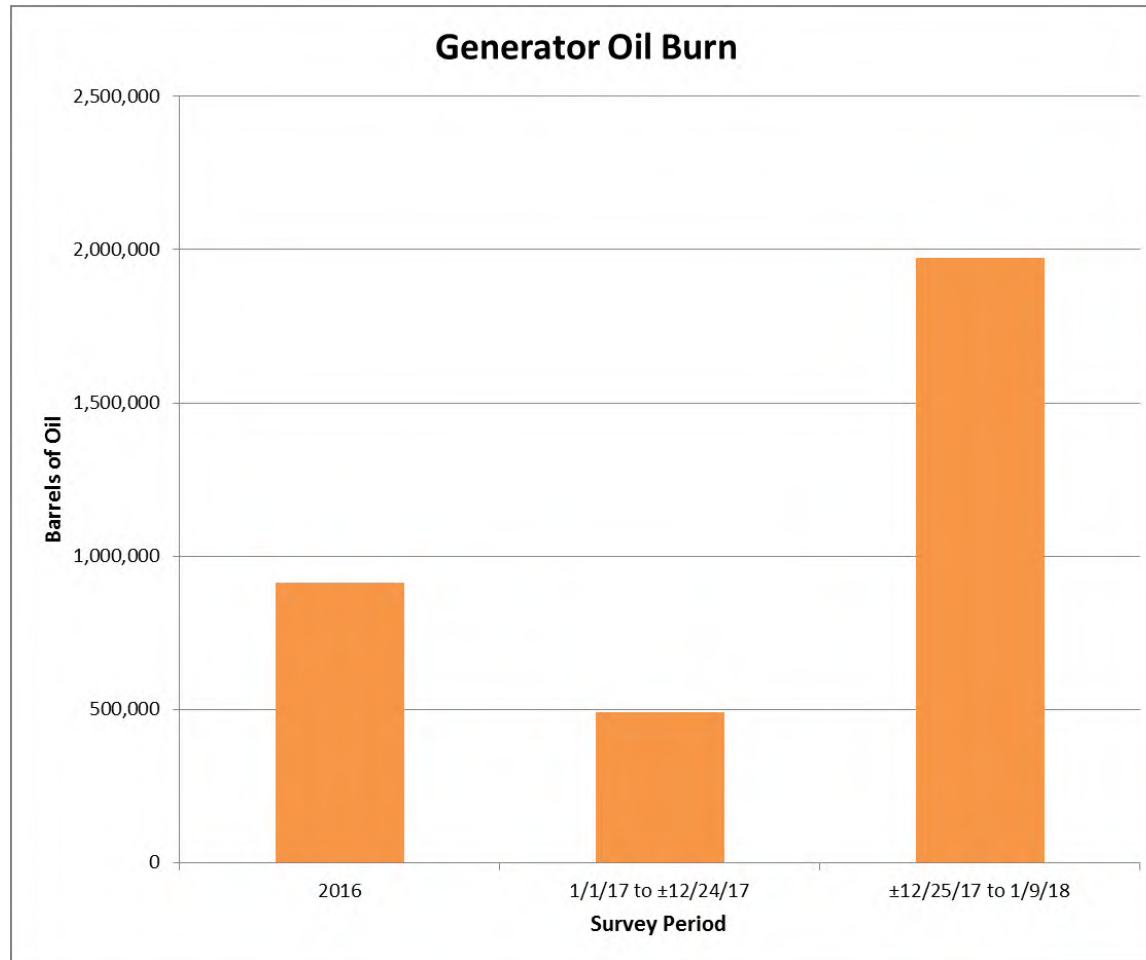
- The Winter Reliability Program data is reported on a monthly basis only and December 2017 data is in the regular NPC report
- Please note that the winter program oil inventory will differ from the actual oil burned during the cold weather for the following reasons
 - Not all units that burn oil participate in the Winter Reliability Program
 - Winter program oil participation is capped at stations, so a station that has a winter program participation of 100K barrels, but has burned 150K barrels is still counted at the original number
 - Actual oil burn numbers reflect the total oil burn and include ongoing replenishments at both dual fuel and oil only stations



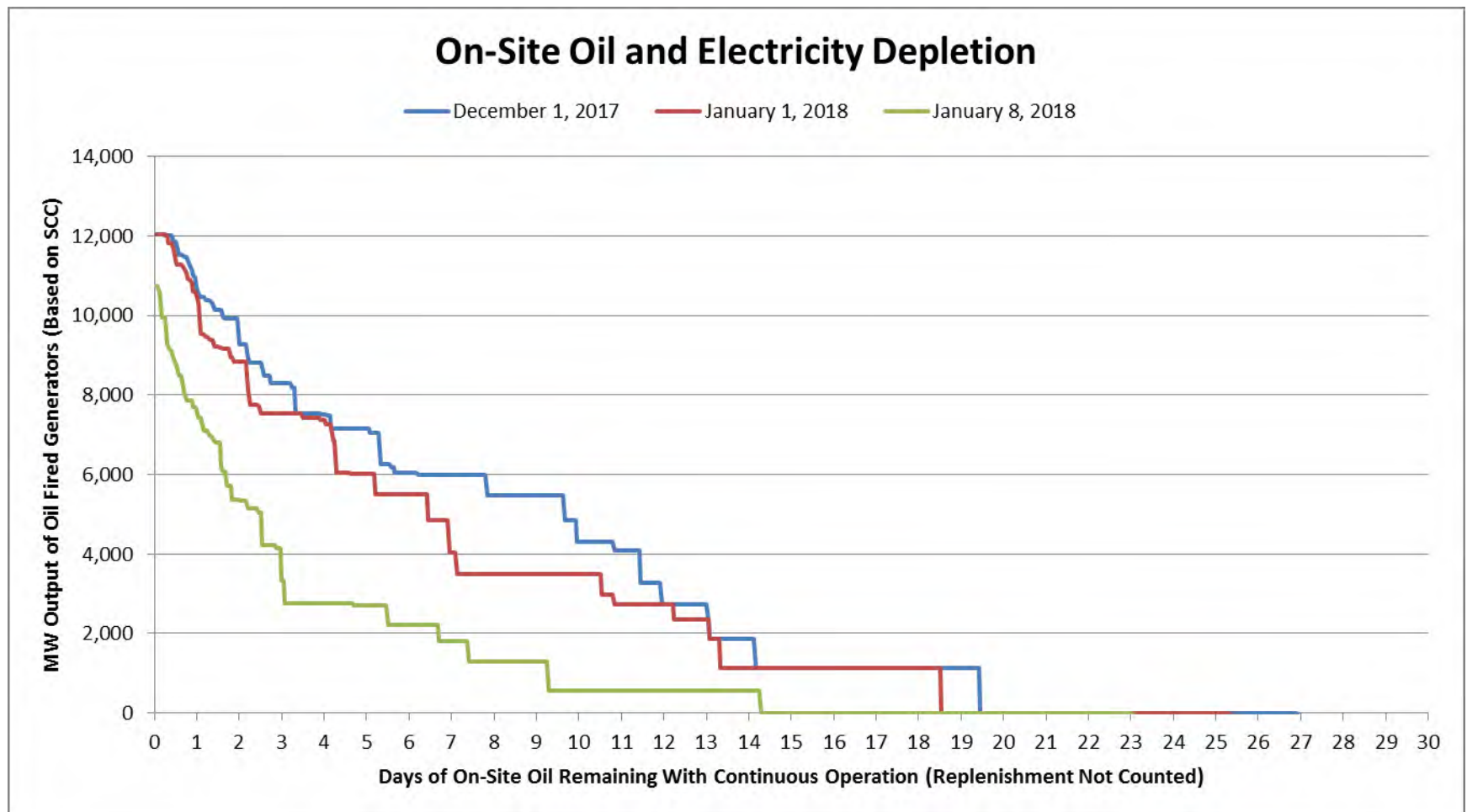
Generator Oil Burn – January 2018



Generator Oil Burn – Yearly Comparison



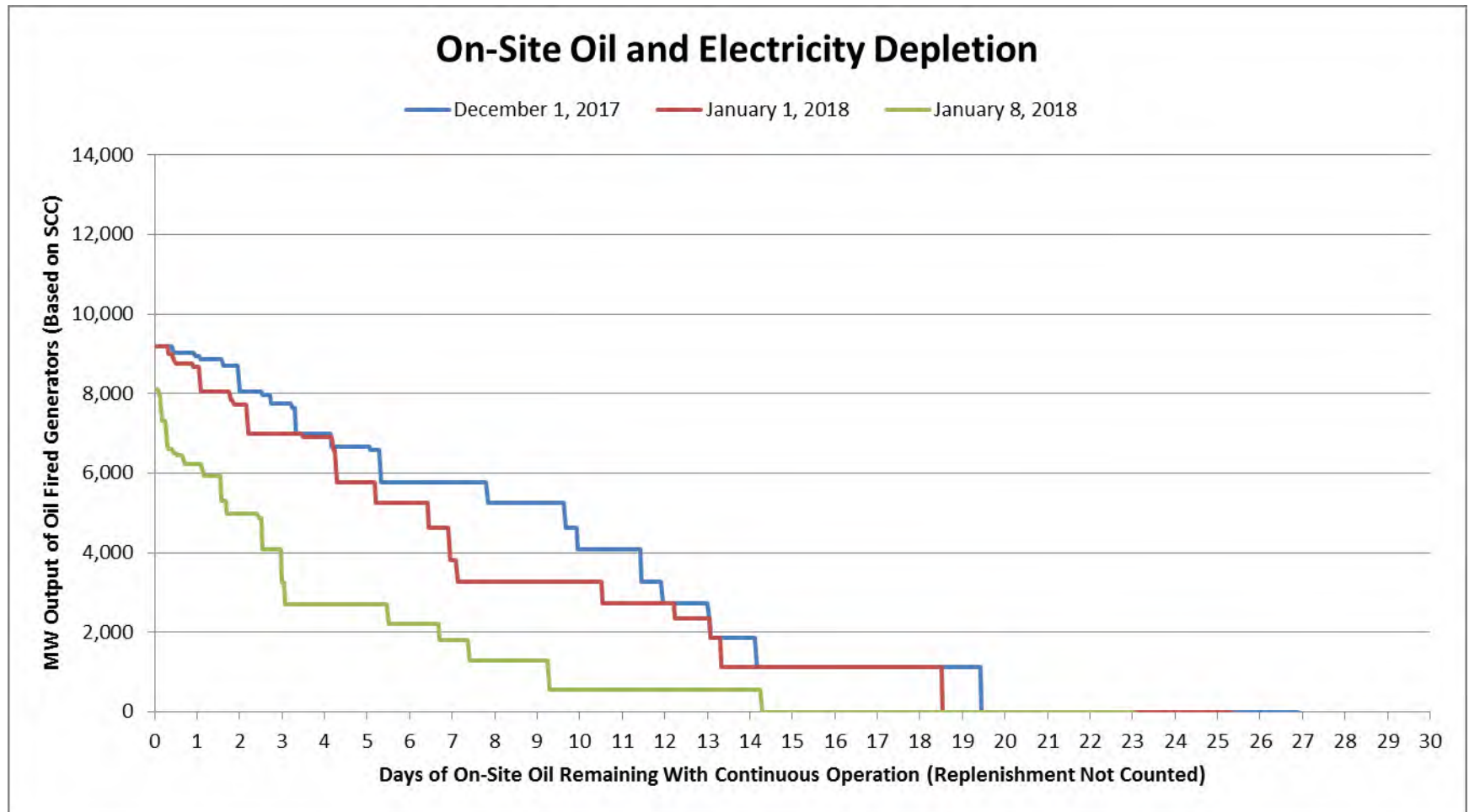
On-Site Oil and Electricity Depletion



This chart is the ISO's best approximation of usable oil discounting for unit outages, reductions, or emissions



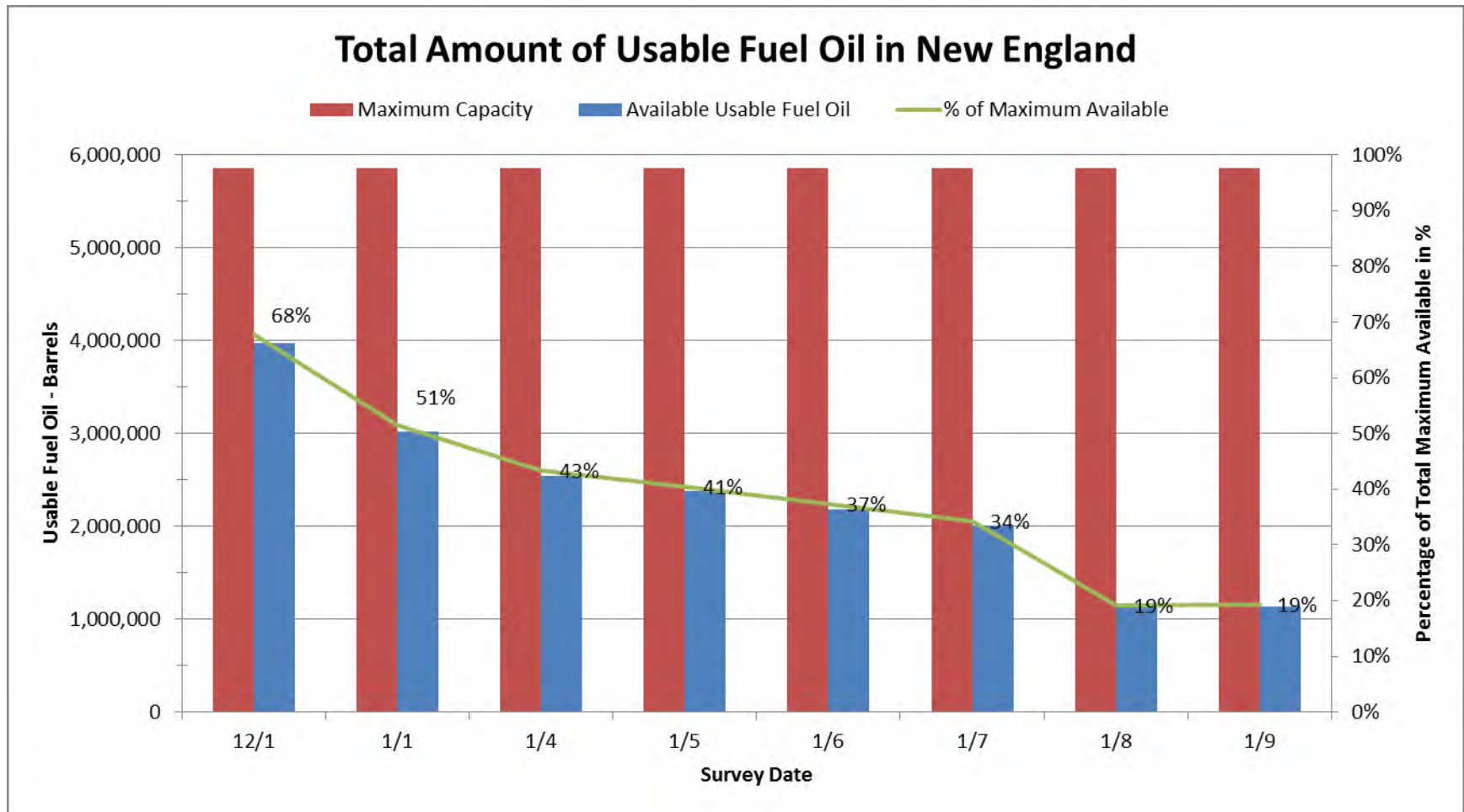
On-Site Oil and Electricity Depletion – Not Including Fast Start Units



This chart is the ISO's best approximation of usable oil discounting for unit outages, reductions, or emissions

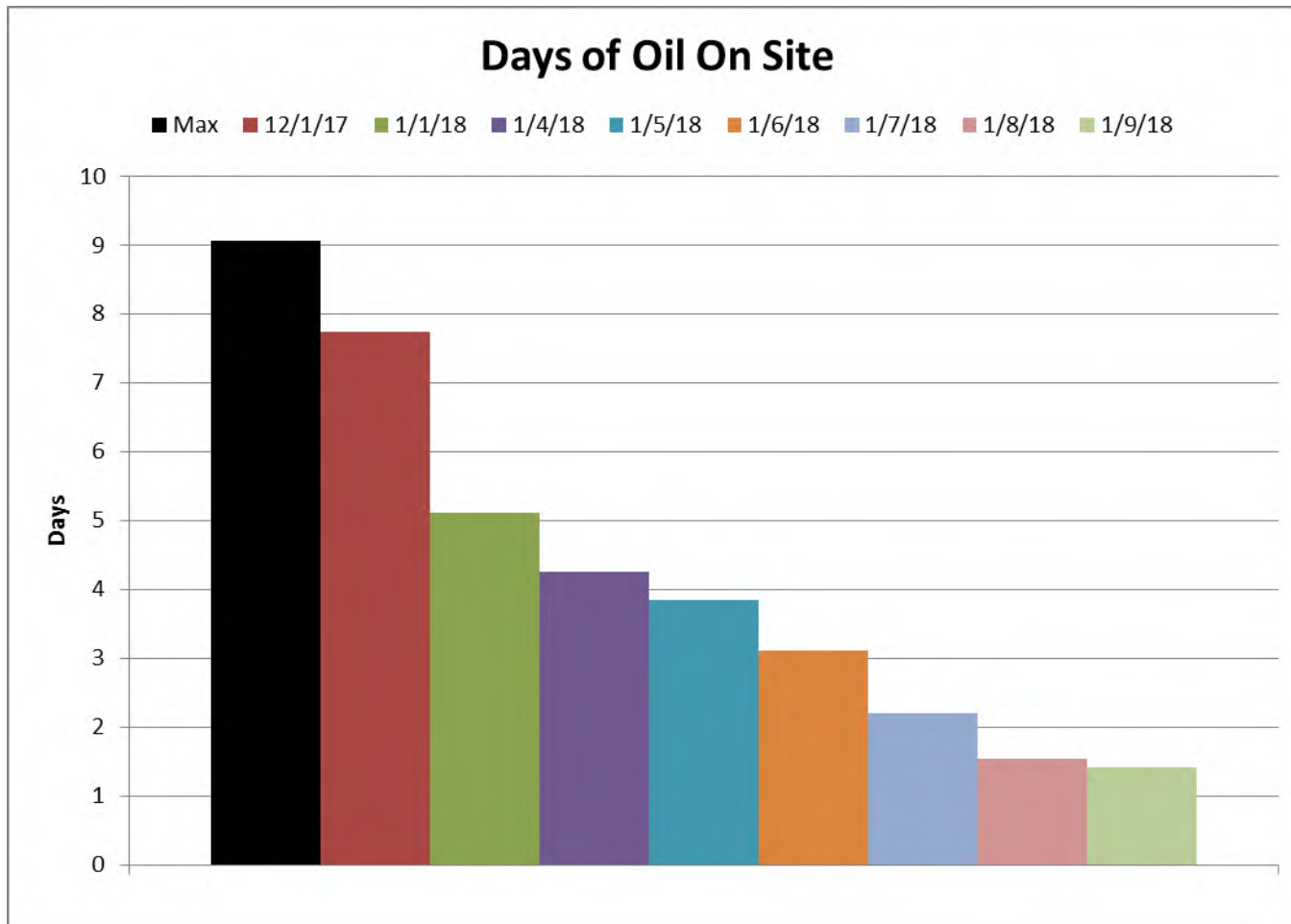


Total Amount of Usable Fuel Oil in New England



This chart is the ISO's best approximation of usable oil discounting for unit outages, reductions, or emissions

Oil Depletion at a Specific Station – An Example



Environmental and Emissions Issues

- With extended days of burning oil, several resources either had concerns about hitting federal and/or state emissions limitations or were impacted by emissions limitations
 - This primarily includes resources in MA, CT and RI
- The ISO is concerned about the availability of the oil burning fleet as it relates to emissions limitations on cold days during the rest of the winter



COLD WEATHER FUEL LOGISTICS



Liquid Fuels Logistics – Oil Terminals (As of Jan 9)

- Most large oil terminals in northern New England have low inventories
- Southern New England terminals are in better conditions
- Sea/river ice has been affecting terminals in NH, ME and Hudson River
- U.S. Coast Guard (USCG) Cutters that are homeported in Maine have been braking ice on NH and ME rivers since mid-December
- The USCG is allowing the Weymouth Fore River Bridge to open to vessel traffic during weekday rush-hours in order to facilitate vital fuel deliveries



Liquid Fuels Logistics – Trucking (As of Jan 9)

- Trucking transport of fuel oil remains the main constraint
 - Trucking of liquid fuels resumed on Friday, January 5th after interruption due to Winter Storm Grayson on January 4th
 - Carriers are at their physical limits
 - Drivers need time off to rest, even with State Waivers in effect
 - The break in the weather this week will provide much needed relief



Liquid Fuels Logistics – Generators (As of Jan 9)

- Power generators who had previously scheduled and paid for fuel oil deliveries are receiving their fuel first, but those who have not are put on a waiting list
- Fuel oil supplies are destined for arrival in northern New England by the end of this week; however, it is expected that power plant demand will quickly consume those re-supplies
- A few smaller power stations have cancelled fuel orders due to lack of trucking



MA Governor Provides Relief for Fuel Deliveries

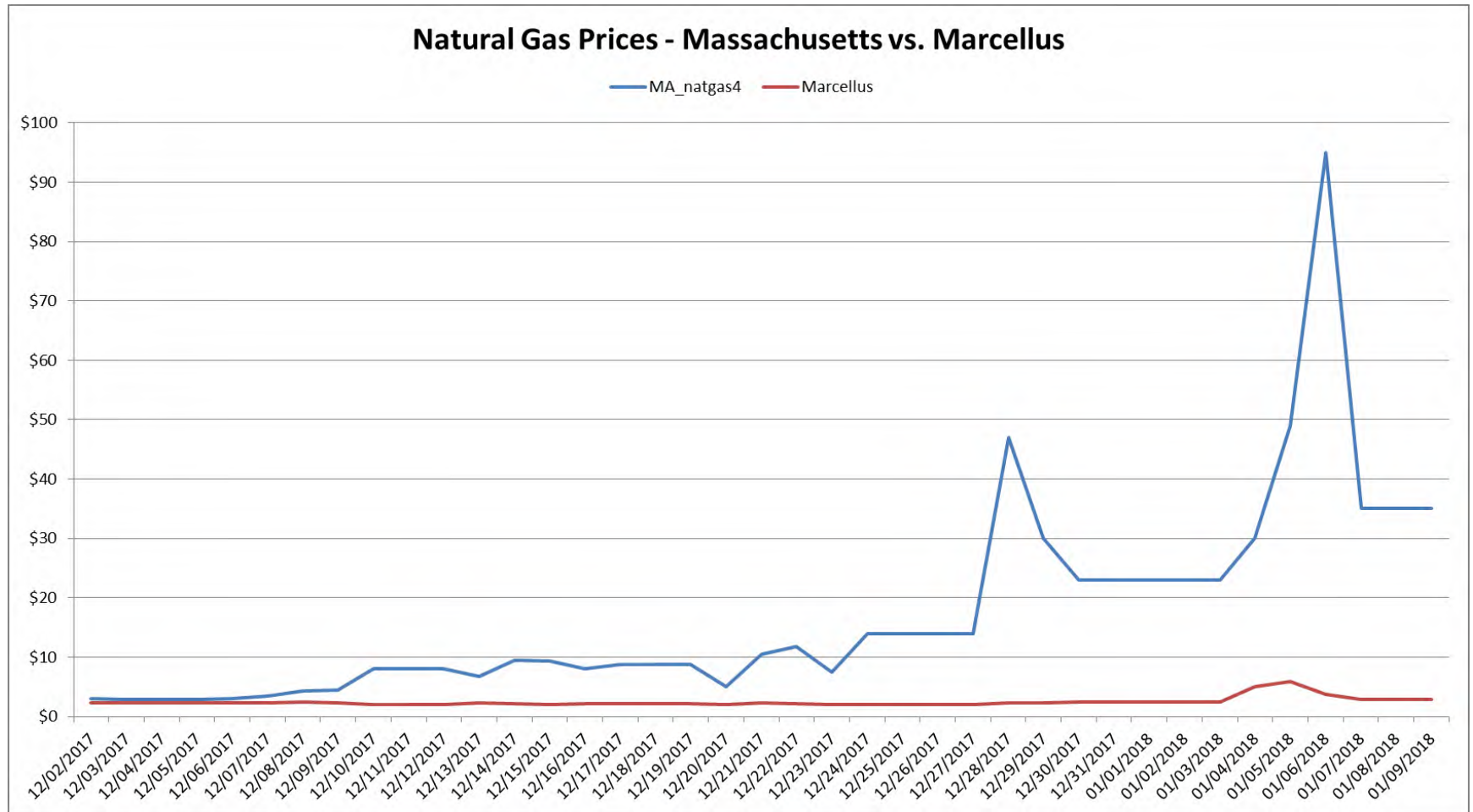
- On Friday afternoon, January 5, Governor Baker signed a revised declaration of emergency that provides relief for fuel deliveries to electric generating facilities until January 19
 - The original declaration, dated December 28, covered fuel deliveries for heating but not electric generating facilities



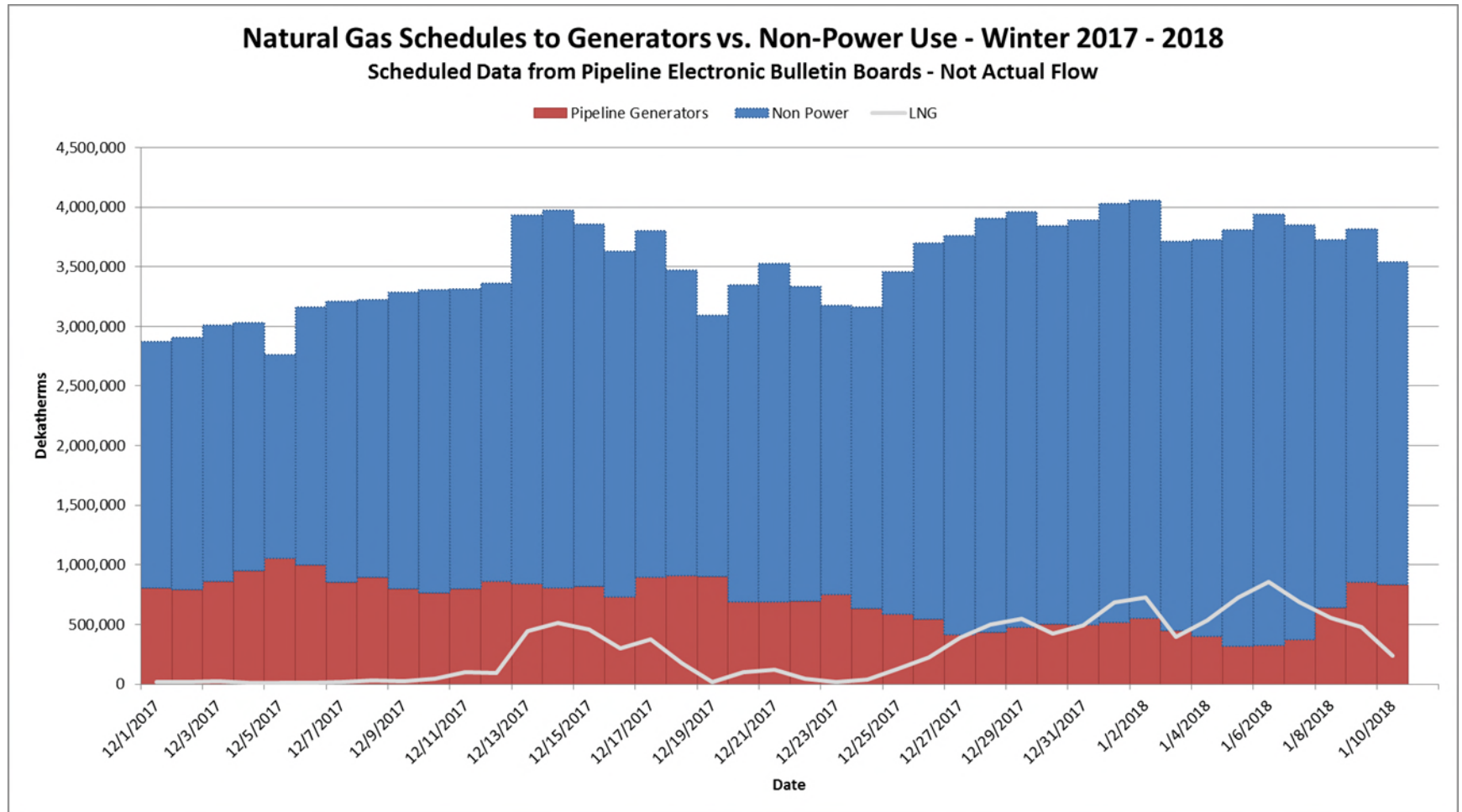
Fuel Surveys

- To increase situational awareness, the ISO initiated twice weekly fuel surveys of oil fired generation beginning on 1/4/18
- Based on system conditions, the periodicity of the fuel surveys was changed to daily beginning on 1/5/18
- Daily fuel surveys are scheduled to continue on a daily basis (Monday-Friday) until further notice
- The Daily Fuel Survey asked participants of oil fired generators questions regarding:
 - Usable Oil Inventory
 - Oil Burn Since Last Survey
 - Plans for Refueling
 - Replenishment Strategies
 - Procurement and Transportation Issues
 - Environmental/Emissions Issues

Natural Gas Prices



Natural Gas Schedules



Natural Gas Issues

- There were 17 reported gas issues for the period between 12/24/17 and 1/8/18
 - Issues were either procurement related or pipeline related
- An Operational Flow Order (OFO) was issued on 12/22/17 with an effective date of 12/25/17 for the Tennessee Gas Pipeline
- An OFO was issued on 12/23/17 for the Algonquin Gas Transmission Pipeline
- An OFO was issued on 12/26/17 for the Iroquois Pipeline
- All three OFOs are still in effect as of 1/10/18



LNG Delivery & Canadian Gas Supply

- LNG send-outs at the Distrigas and Canaport facilities are critical to winter operations
 - Both Distrigas and Canaport received LNG cargos during the cold weather event (or) shortly thereafter
- Sable Island and Deep Panuke are operating at low levels, producing approximately 130,000 MMBTU/day



SYSTEM OPERATIONS



System Operations: Communications

- Emergency conference calls were held with NPCC Reliability Coordinators to review the following:
 - Expected weather and peak loads for the current and next day
 - Expected MW surplus above the operating reserve requirements
 - Confirmed expected interchange schedules
 - Conditions of natural gas supply and fuel oil inventory
 - Dates of calls: 12/24, 12/28, 12/29, 1/1, 1/2, 1/3, 1/5, 1/7
- Emergency conference calls with the six Local Control Centers in New England to discuss the following:
 - Expected peak load conditions in New England and known issues with generation units
 - Known concerns with the natural gas interstate pipes
 - Known concerns with fuel oil inventory and transportation limitations
 - Dates of calls: 12/24, 12/29, 1/3, 1/5, 1/7, 1/8

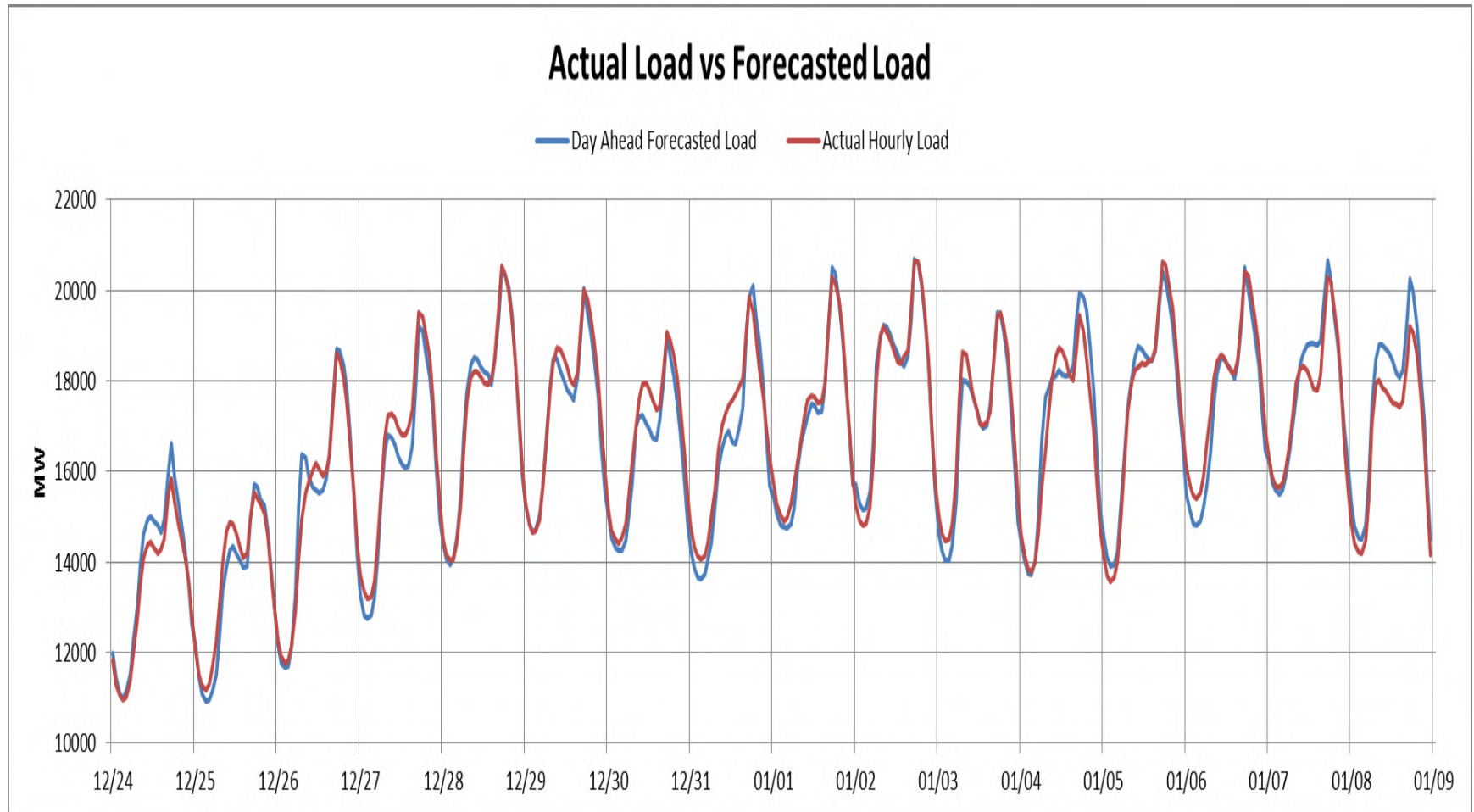


System Operations: Communications, cont.

- ISO New England requested conference calls with the Northeast Gas Association/Gas Supply Task Force (NGA/GSTF) members to discuss the following:
 - The overall condition of each interstate pipeline supplying New England
 - The overall condition of LNG supplying New England
 - Dates of calls: 12/27, 1/5
- ISO New England was in daily communications with interstate pipeline operators



System Operations: Actual vs. Forecasted Load



System Operations: M/LCC 2

- M/LCC 2, Abnormal Conditions Alert, was declared on 1/3/18 @ 16:00 for all of New England due to the extreme weather followed by forecasted extreme cold as well as fuel supply concerns
- M/LCC 2 was cancelled on 1/9/18 @ 12:00



System Operations: Maintenance

- Impact on Transmission and Generation Maintenance:
 - 2 significant generation resources (approx. 800MW of capability) had planned outages/reductions rescheduled
 - 2 transmission line outages were rescheduled for a later date



System Operations: Transmission

Significant Transmission Events:

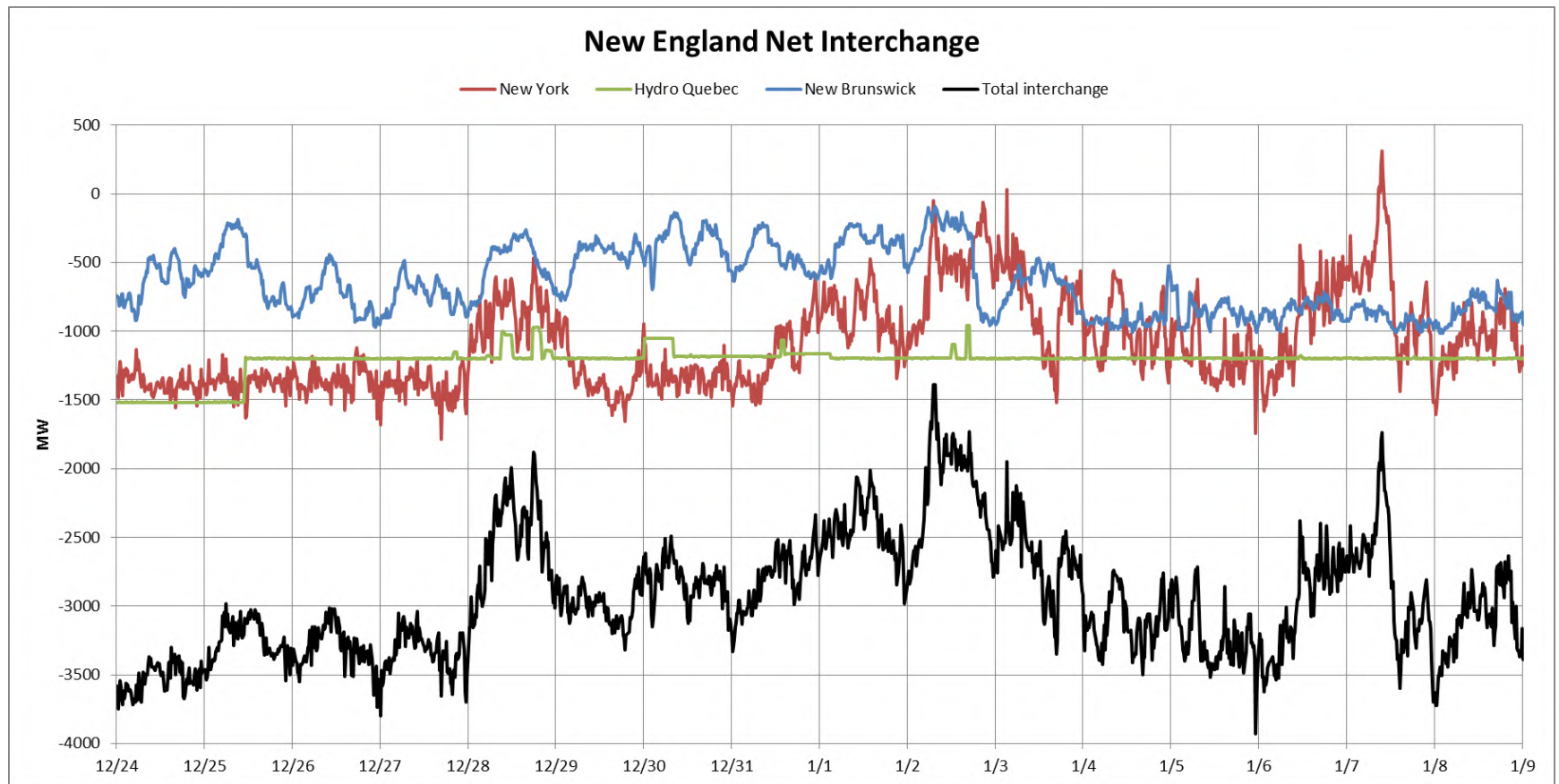
Facility	Zone	Start Date	Return Date	Reason/Impact
HQ Phase II Pole 2		12/25/17	1/14/18 (expected)	TTC reduction by 1000MW/Reduced to ½ capacity
345 kV line	SEMA/RI	12/25/17	12/29/17	Replace failed structure
345 kV line	SEMA/RI	12/29/17	12/30/17	Structure fire
345 kV line	SEMA/RI	1/4/18	1/7/18	Storm Grayson/Loss of Pilgrim plus 300MW reduction on nearby generation facility
345 kV line	SEMA/RI	1/5/18	1/7/18	Equipment trip

System Operations: Interchange

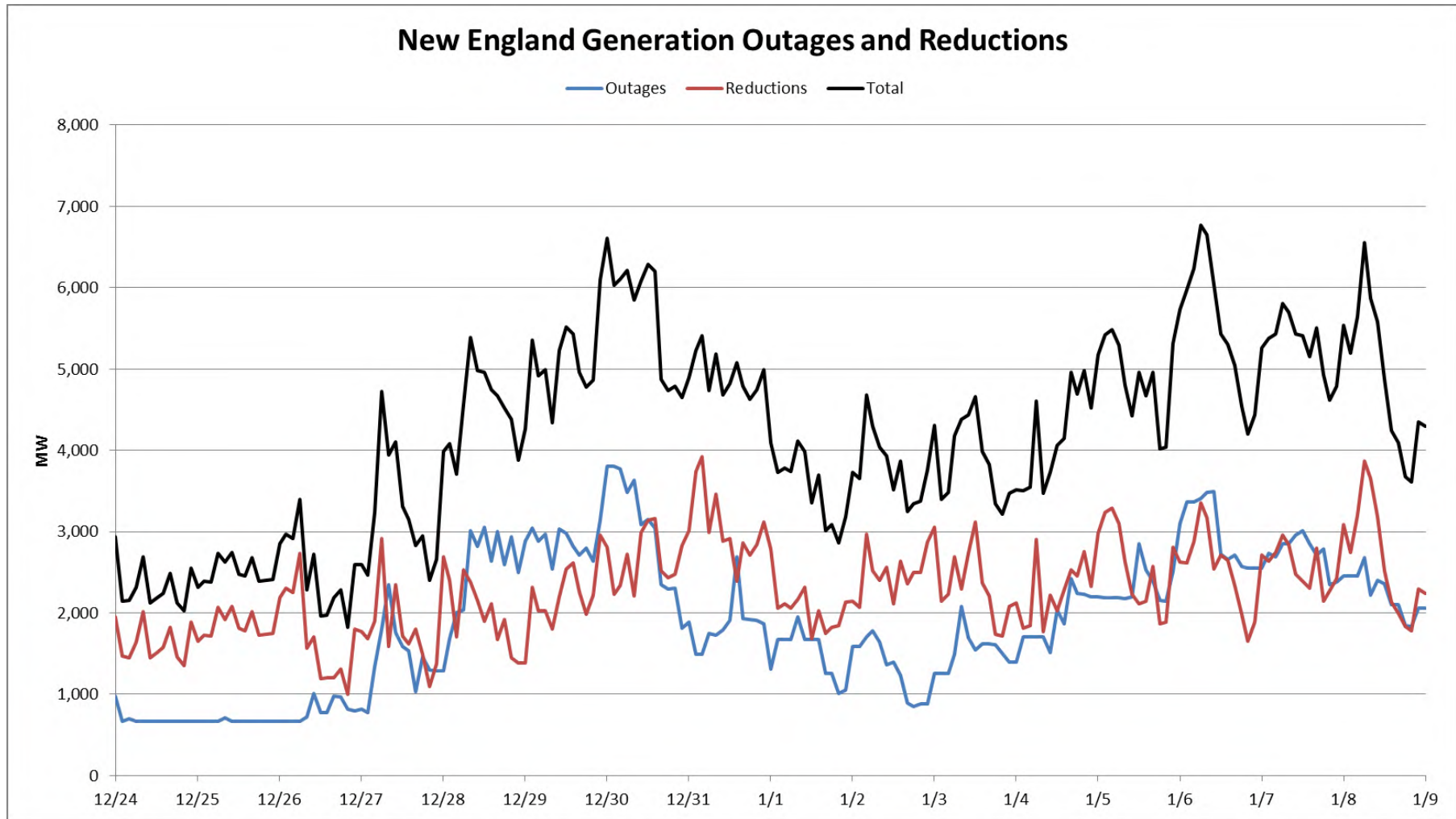
- Increase in Scheduling Limit with NYISO
 - At 16:00 on 1/3/18, the scheduling limit on the NY A.C. ties was increased from 1,400 to 1,600MW
 - The increased limit was made possible by the cold conditions which helped to improve thermal transfer capability



Actual Interchange – By Scheduling Region (Negative values indicate Imports)



Generation Outages and Reductions



Generation Fleet Performance

- The aggregate performance of the available generation fleet over the duration of the cold spell was good
- Communication with generator Designated Entities was very good and was key to maintaining situational awareness
- The cold weather has subsided, however oil inventories are still depleted in New England
- In preparation for the next round of cold weather, it is essential that oil inventories are replenished



System Operations: Commitment Challenges

- Significant challenges associated with the continuous monitoring of the fuel inventories of oil-fired generation to ensure commitments did not jeopardize the long term availability of resources
- Several oil-fired generators were postured to conserve oil and ensure system reliability
- On numerous occasions, high load projections in Hydro Quebec created uncertainty in the availability of deliveries over the Phase II and Highgate interfaces

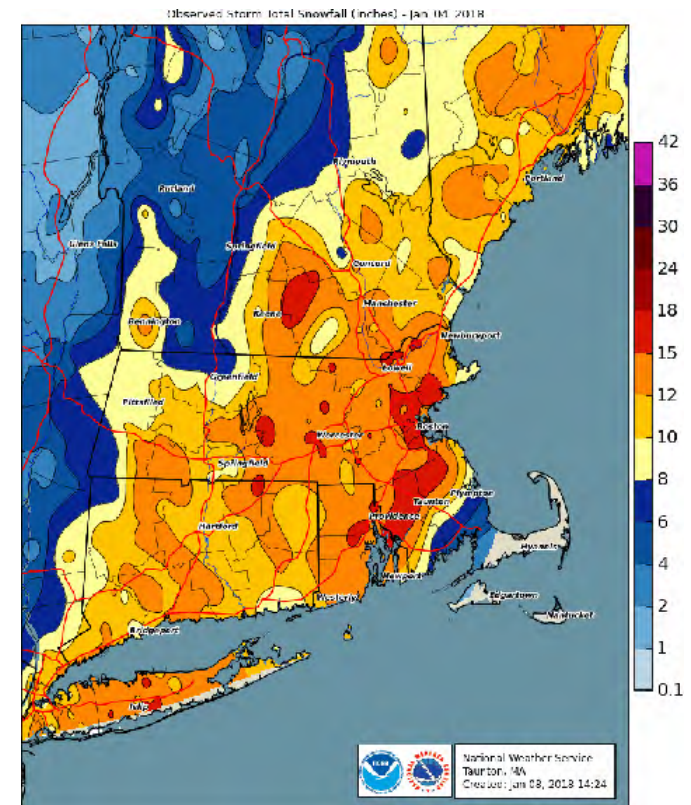


PV AND WIND OUTPUT

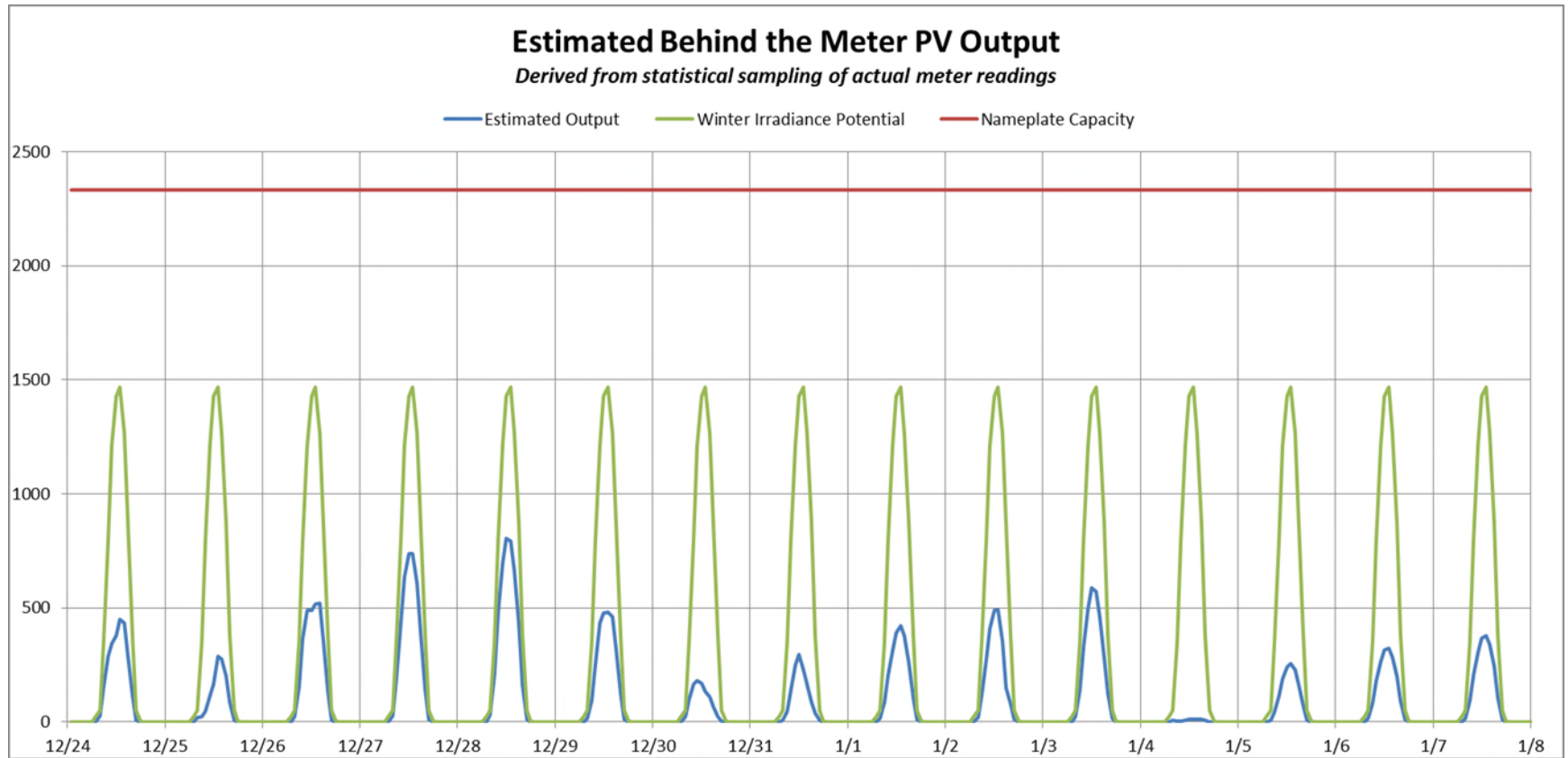


Impact of Snowfall on Energy from PV

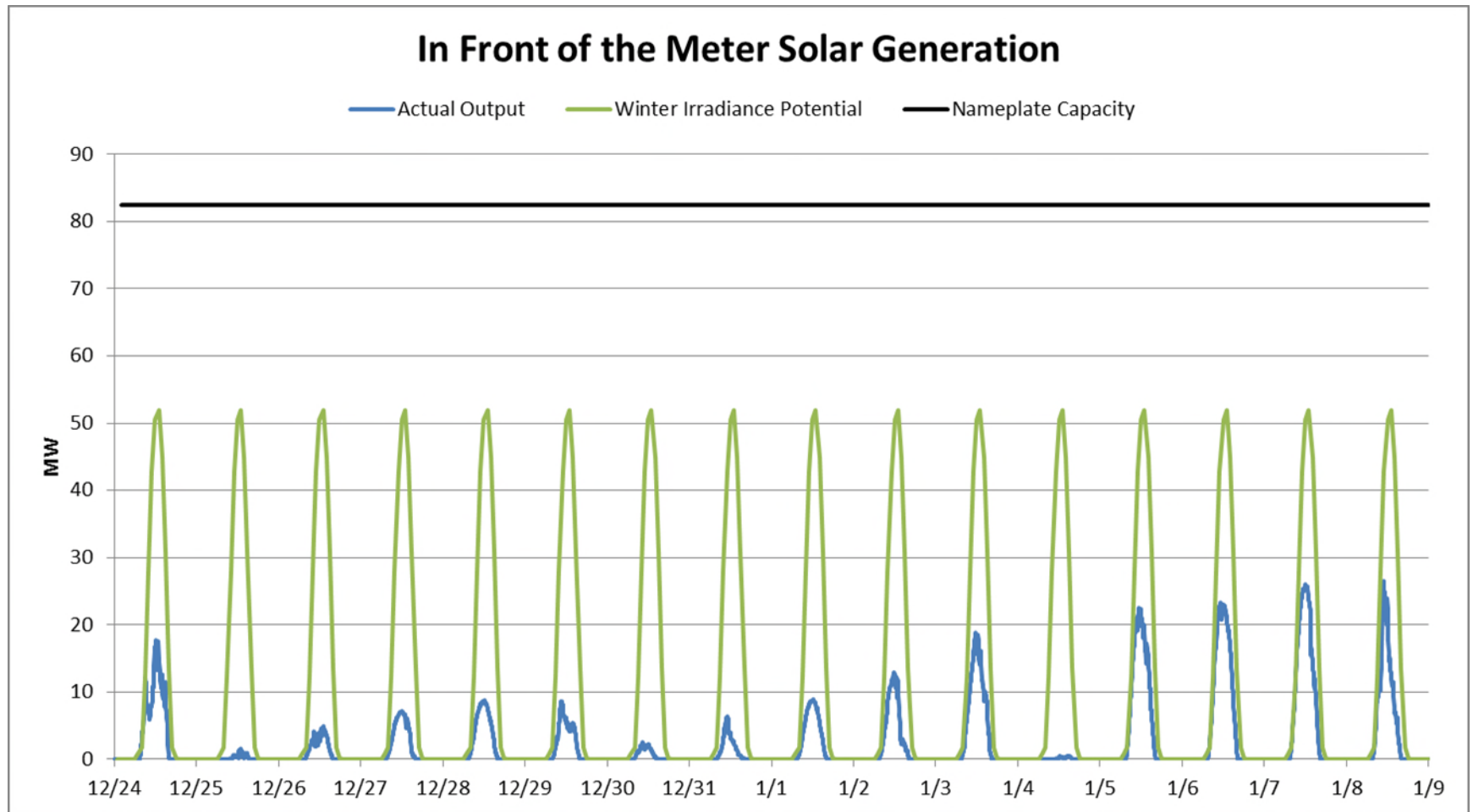
- Snowfall followed by cold weather led to uncertainty of load forecast accuracy
- It is necessary to continue to improve the understanding of snowfall on PV resources in New



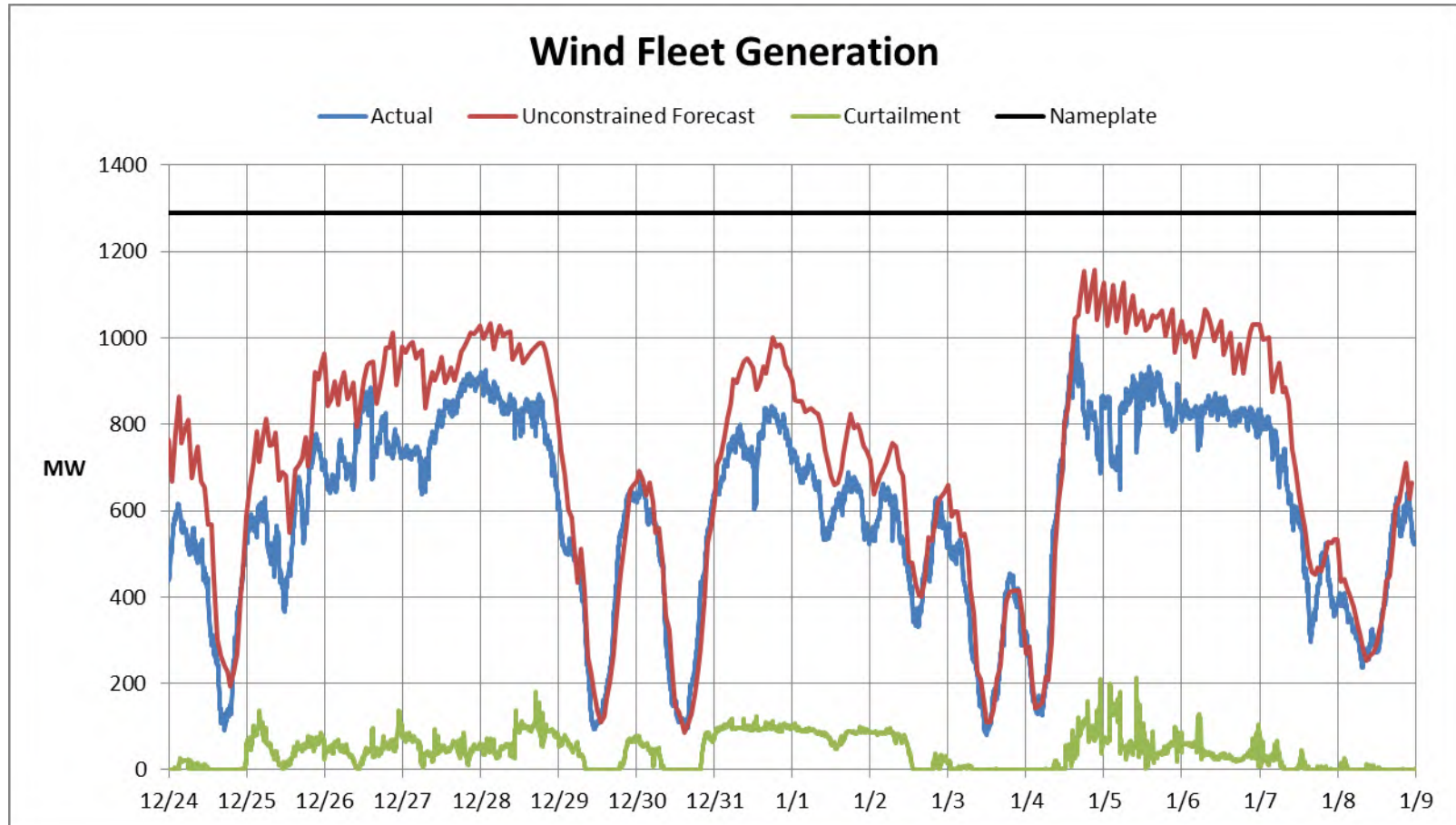
PV Generation – Behind the Meter



PV Generation – In Front of the Meter



Wind Generation

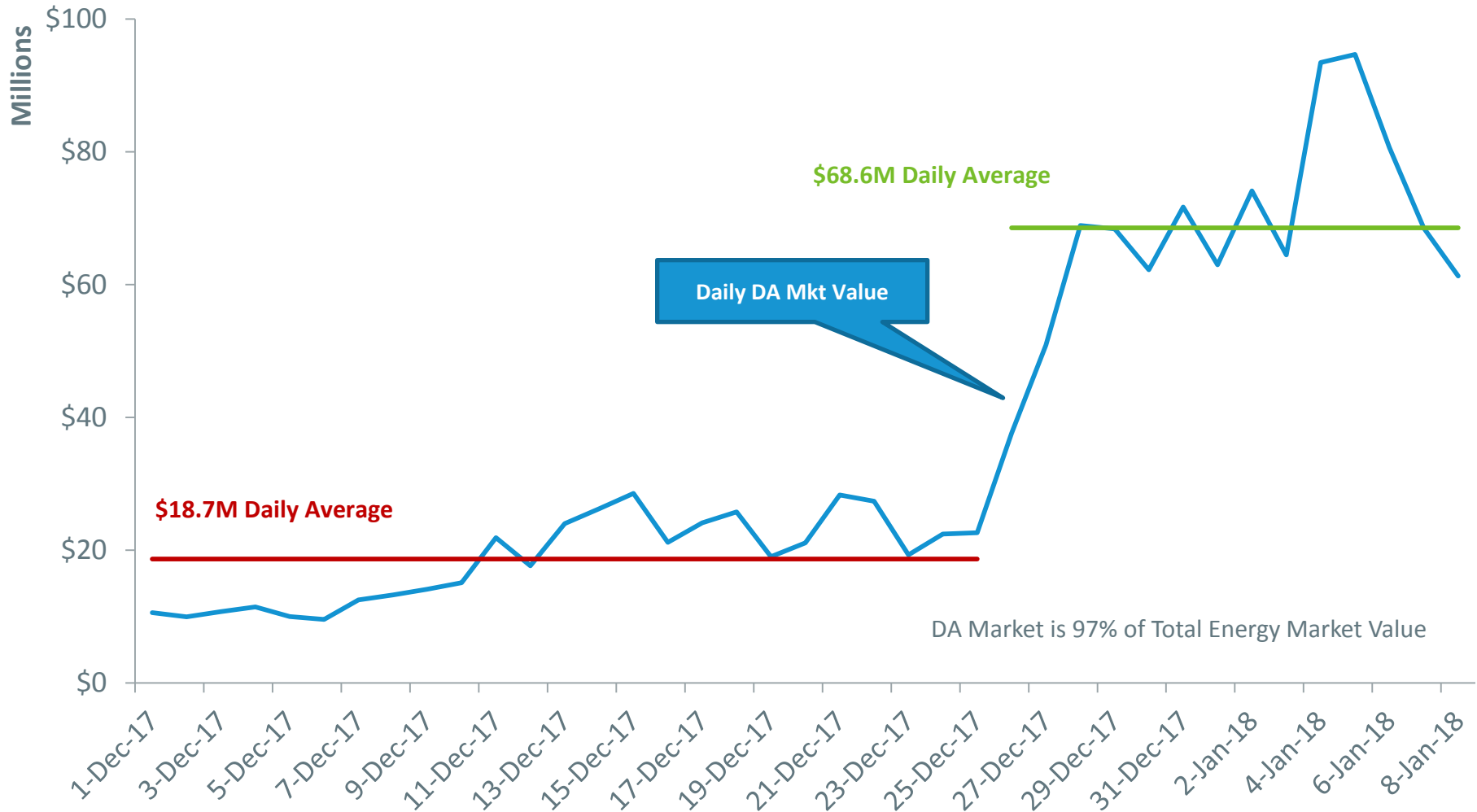


After 00:01 on 1/5/18, several wind plants in the region experienced intermittent high speed wind cutout events. Curtailments are due to transmission congestion.

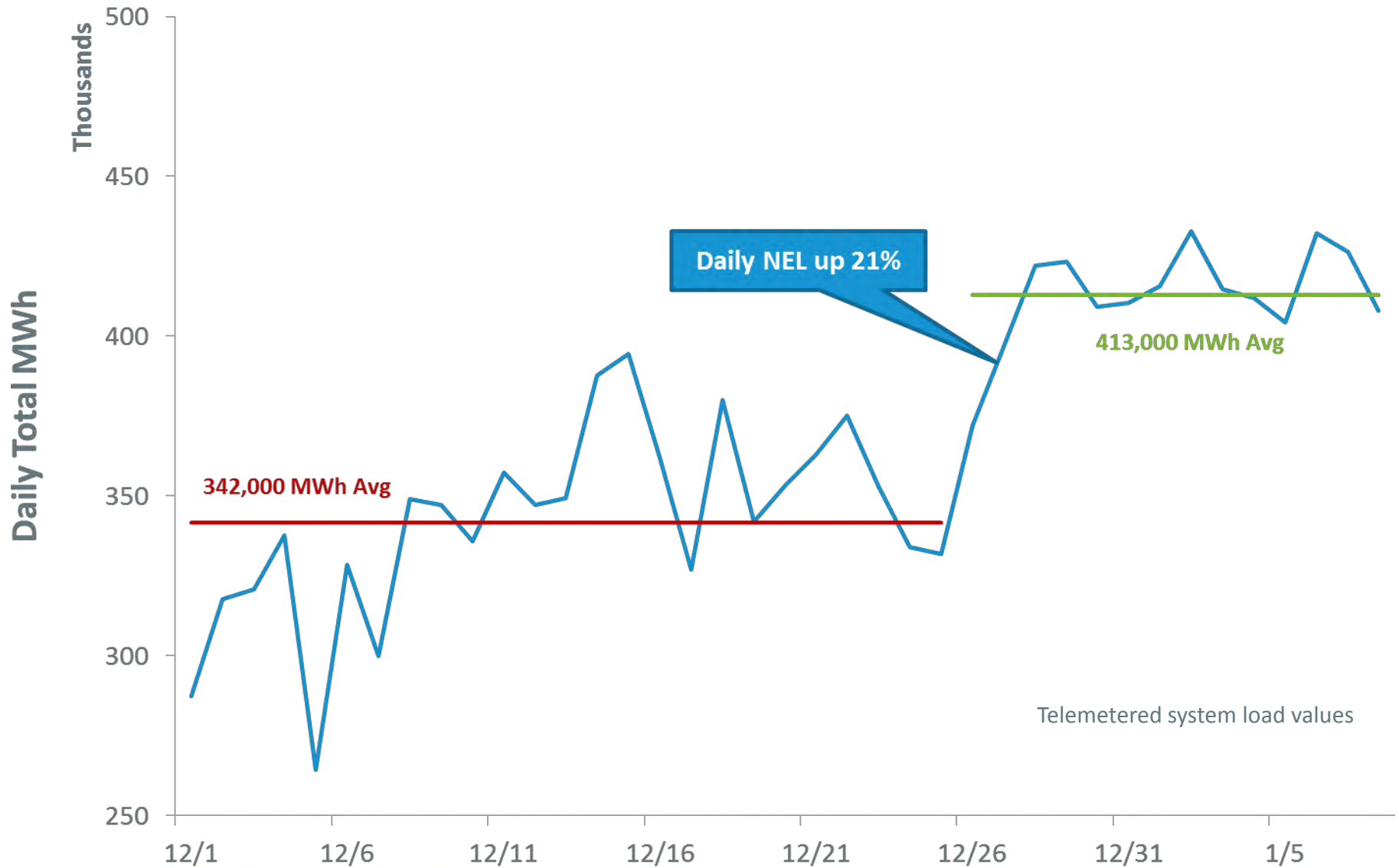
MARKET DATA



Daily DA Market Cost Before and During the Cold Snap

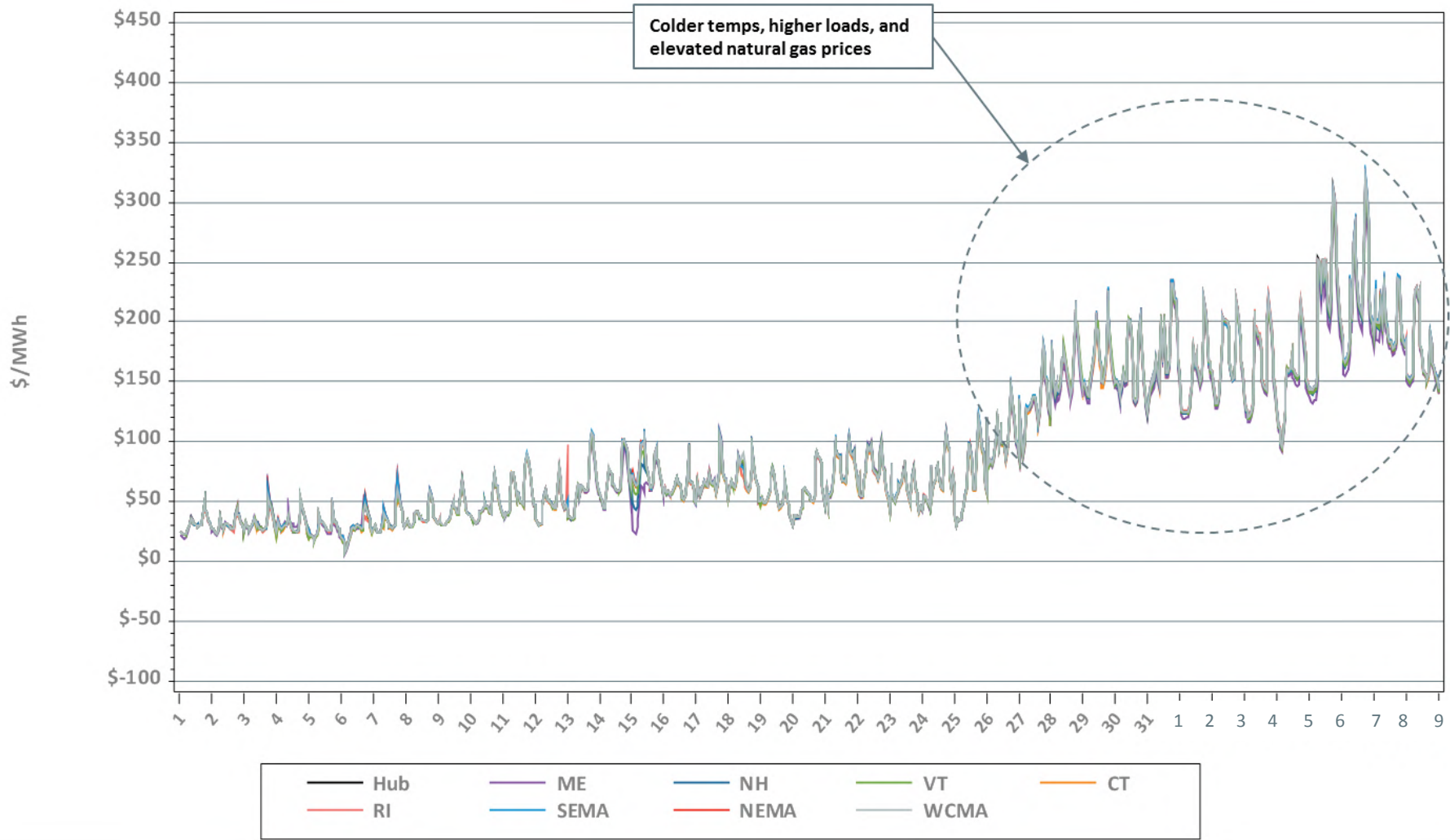


Daily System Load Increased 21% after Christmas



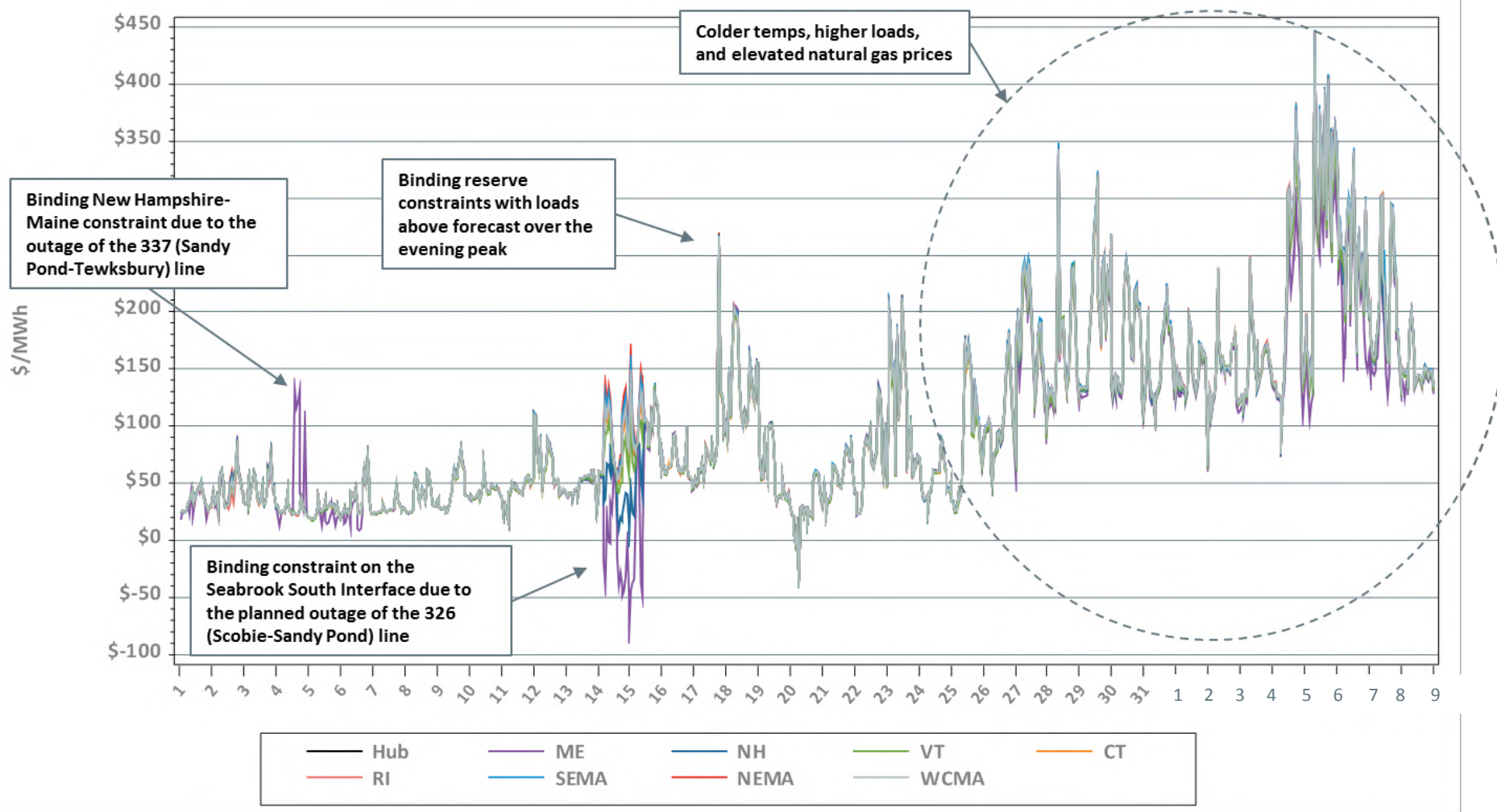
Hourly DA LMPs, December 1-January 8

Hourly Day-Ahead LMPs



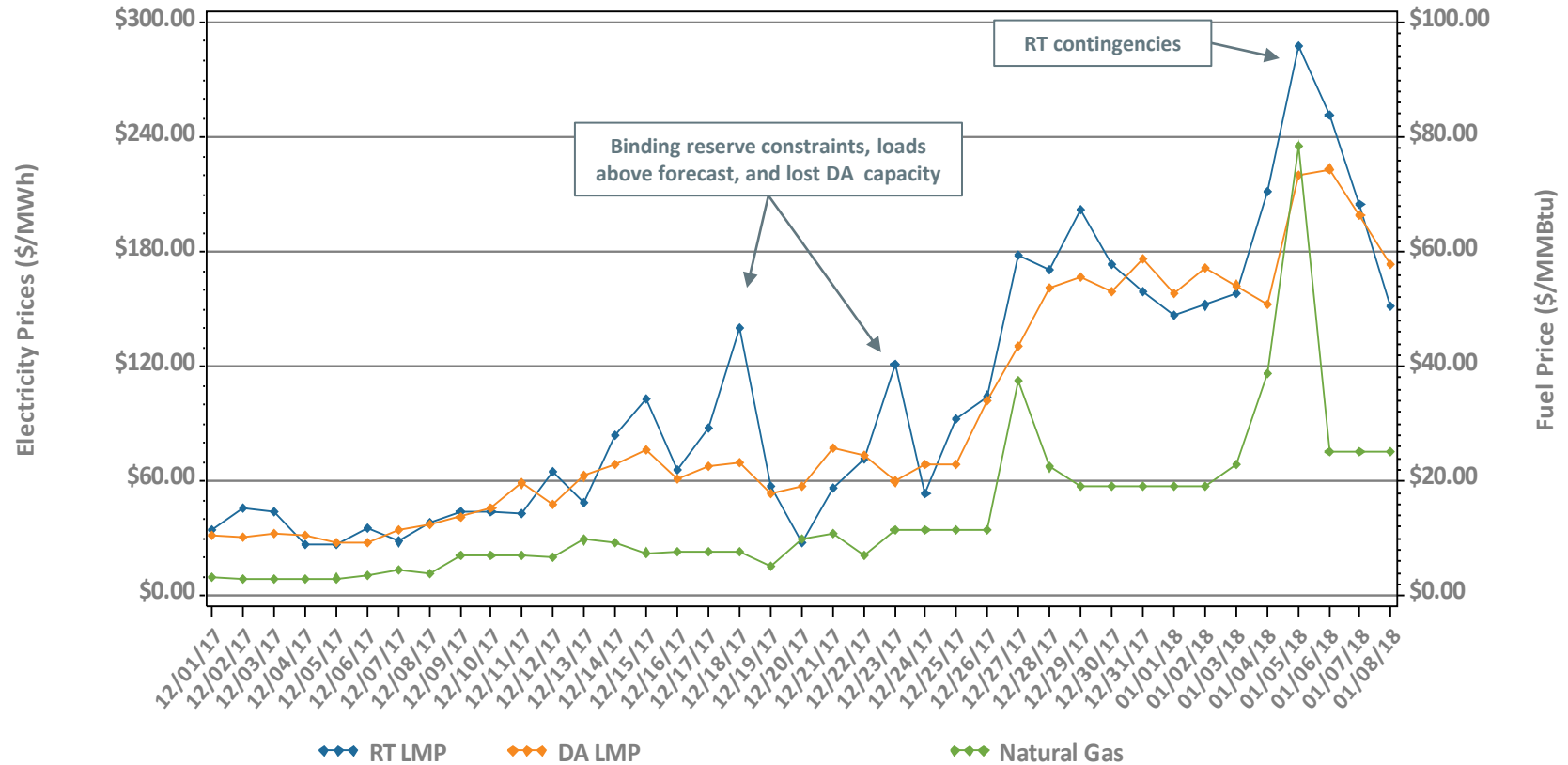
Hourly RT LMPs, December 1-January 8

Hourly Real-Time LMPs



* No Minimum Generation Emergencies were declared during the period.

Daily Avg. DA and RT ISO-NE Hub Prices and Input Fuel Prices: December 1-January 8

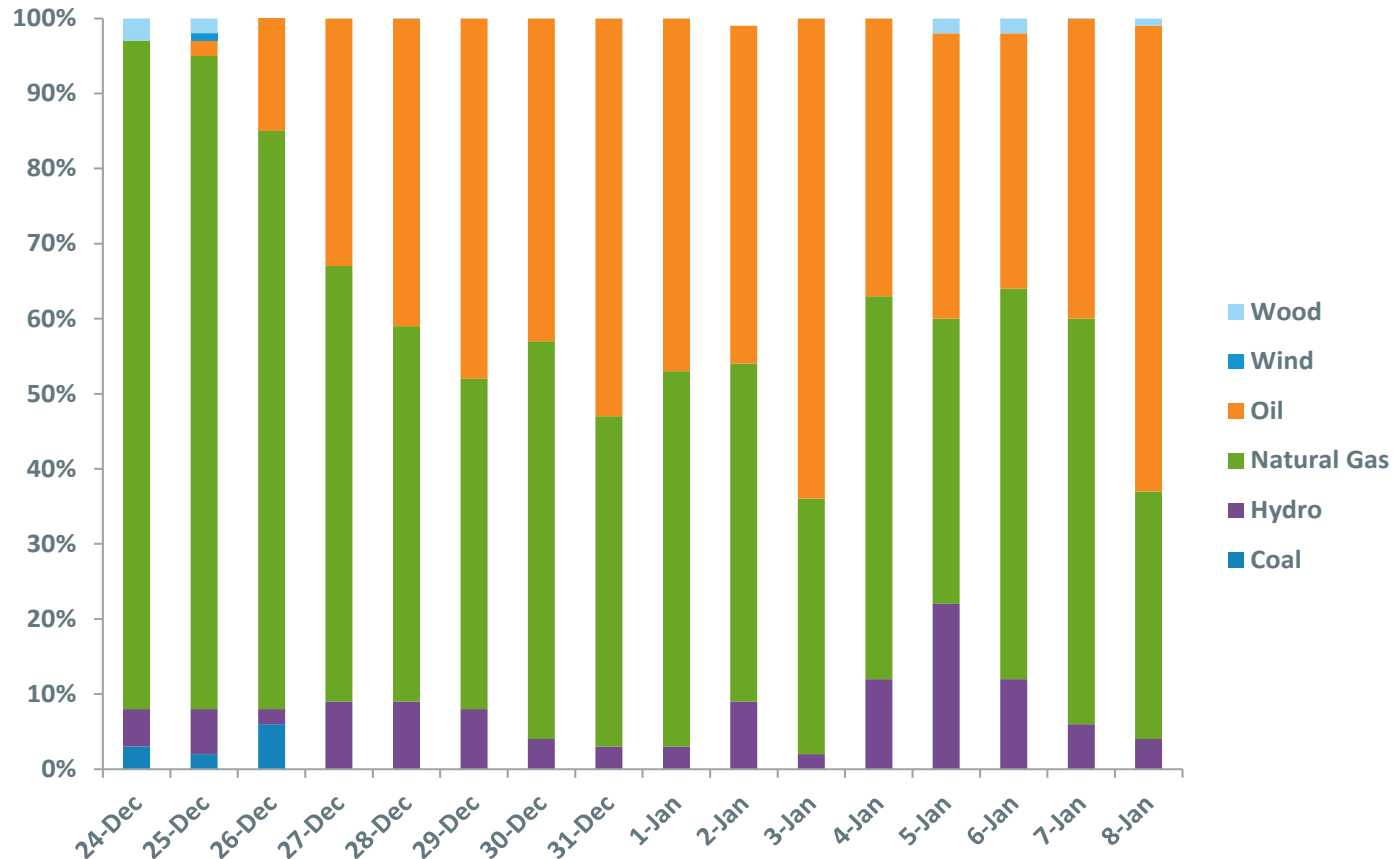


Underlying natural gas data furnished by:



Average price difference over this period (DA-RT): \$-12.91
 Average price difference over this period ABS(DA-RT): \$27.19
 Average percentage difference over this period ABS(DA-RT)/RT Average LMP: 14%
 Gas price is average of Massachusetts delivery points

Oil Increasingly on the Margin during Dec. 24-Jan. 8

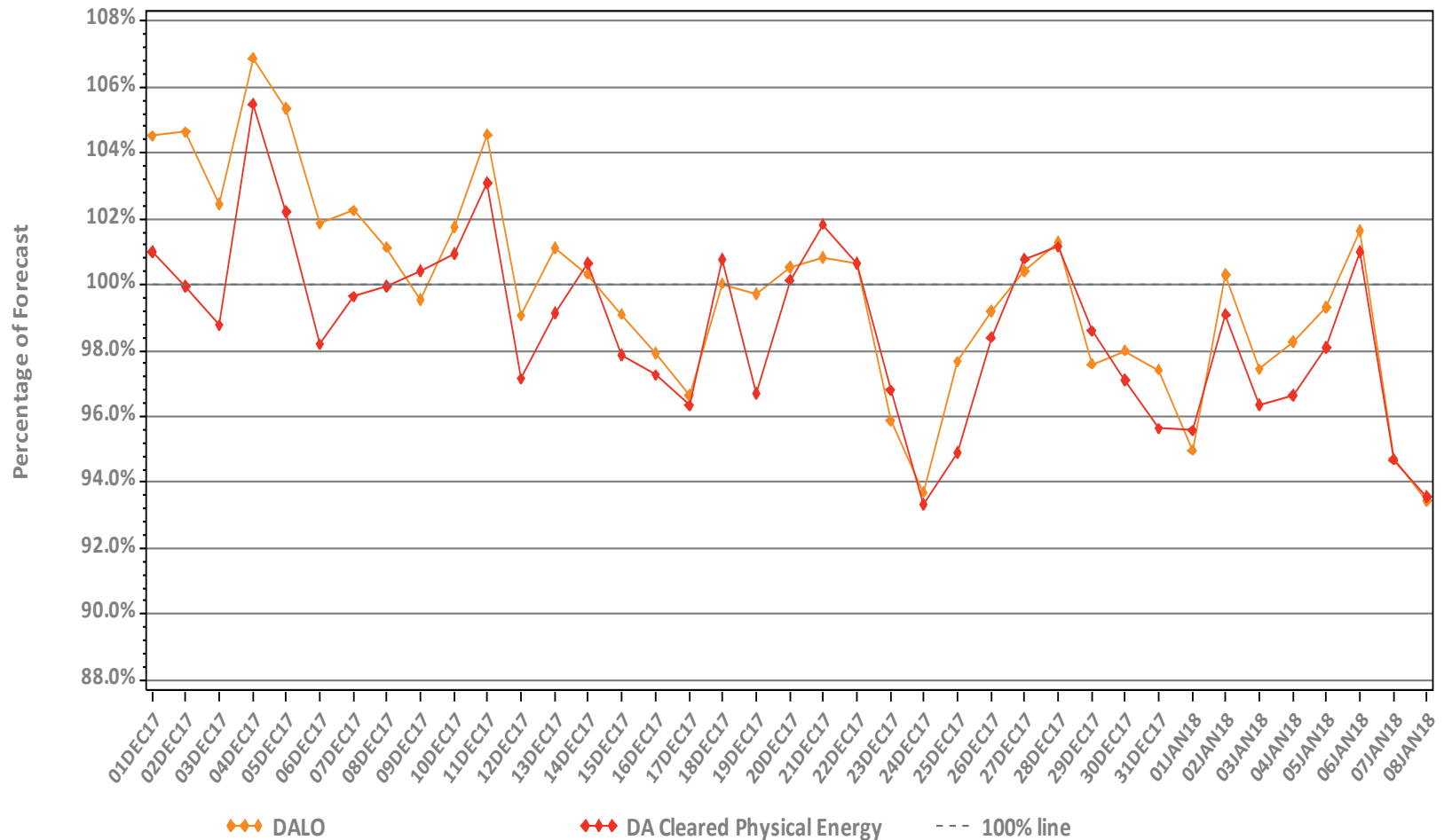


Note: Reflects price-setting by fuel-type during all intervals when the transmission system was unconstrained



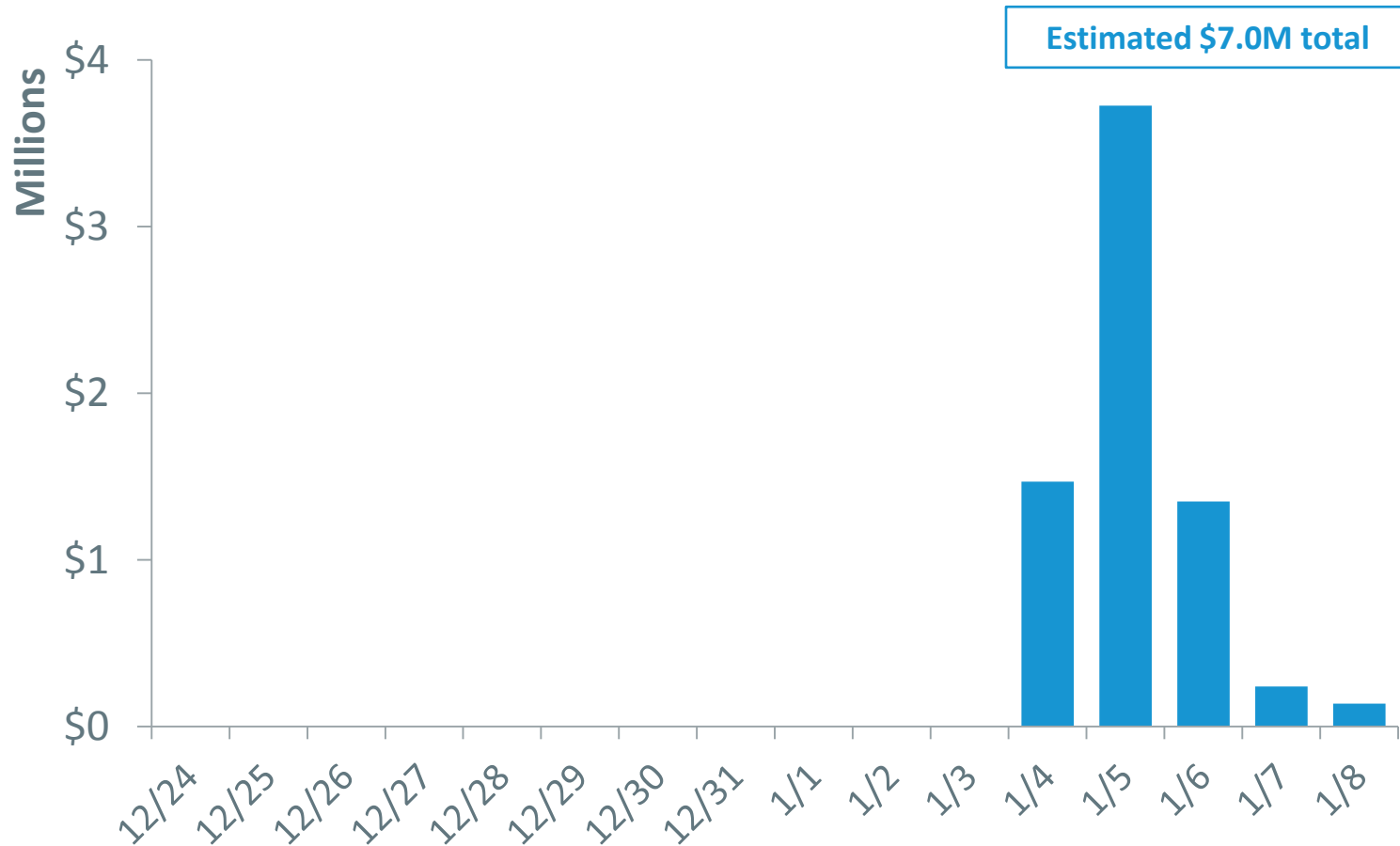
DA Volumes as % of Forecast in Peak Hour

Daily: This Month



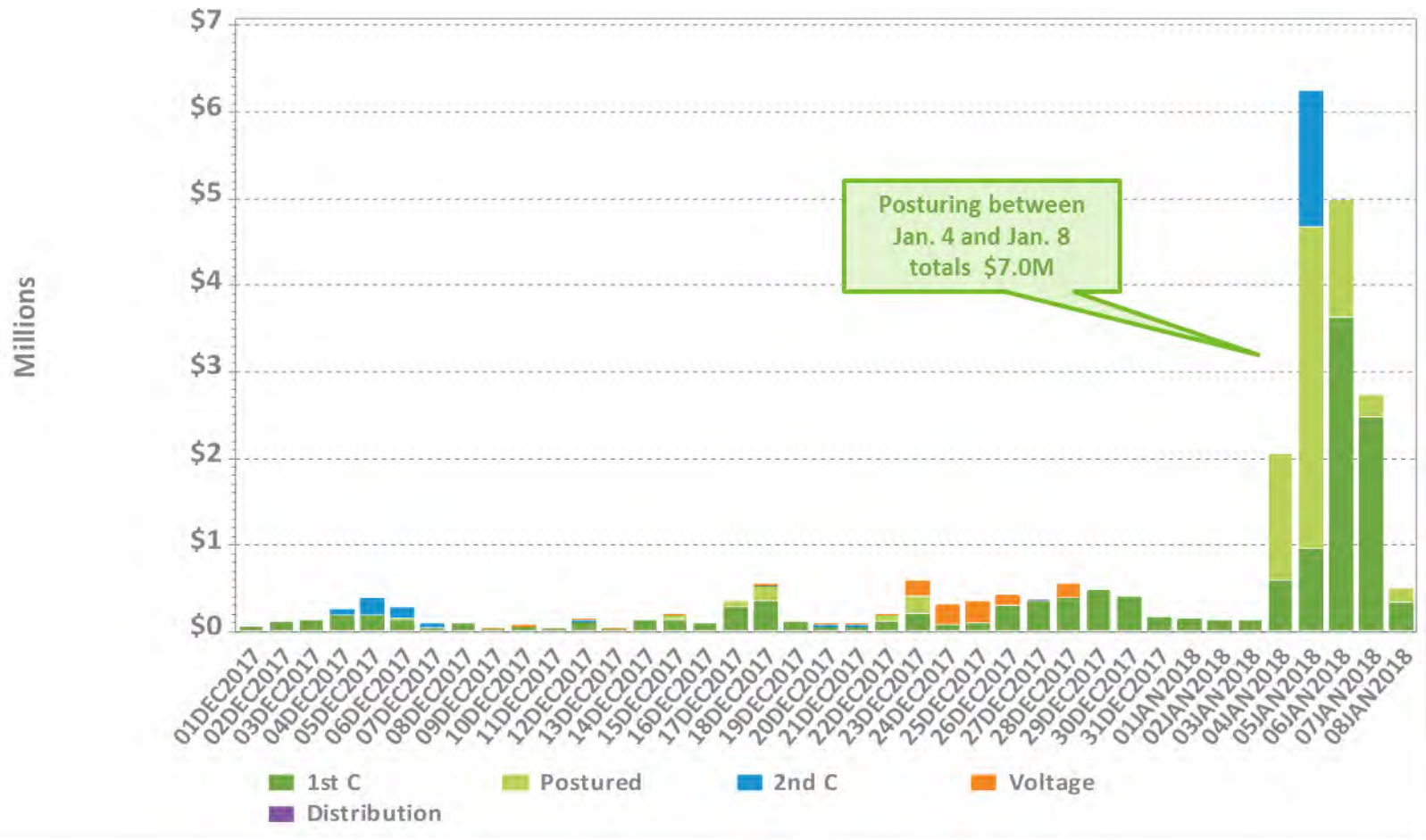
Note: DA Cleared Physical Energy includes DA generation and net imports

Real-Time Posturing NCPC



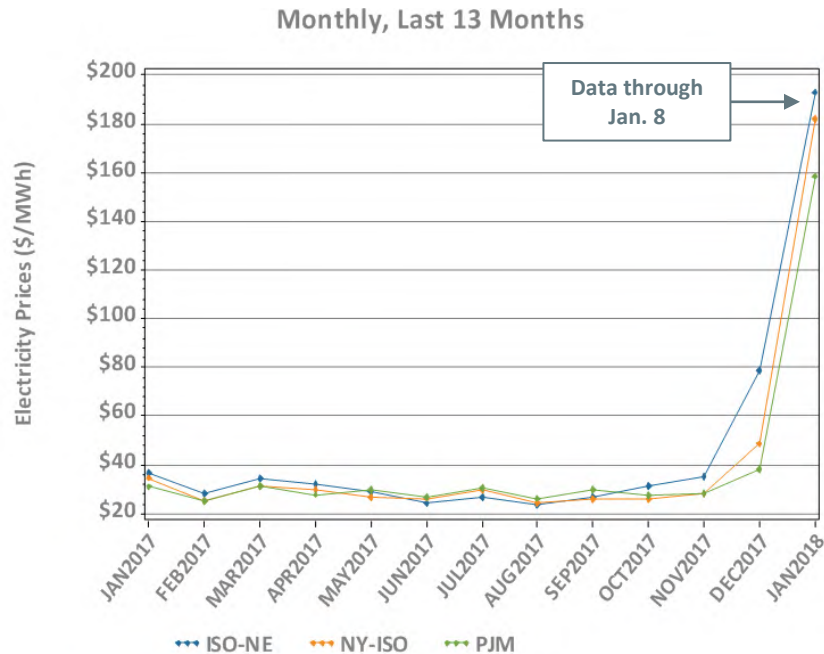
Does not show 'totals' of generation deviations charged to postured resources

Daily NCPC Charges by Type

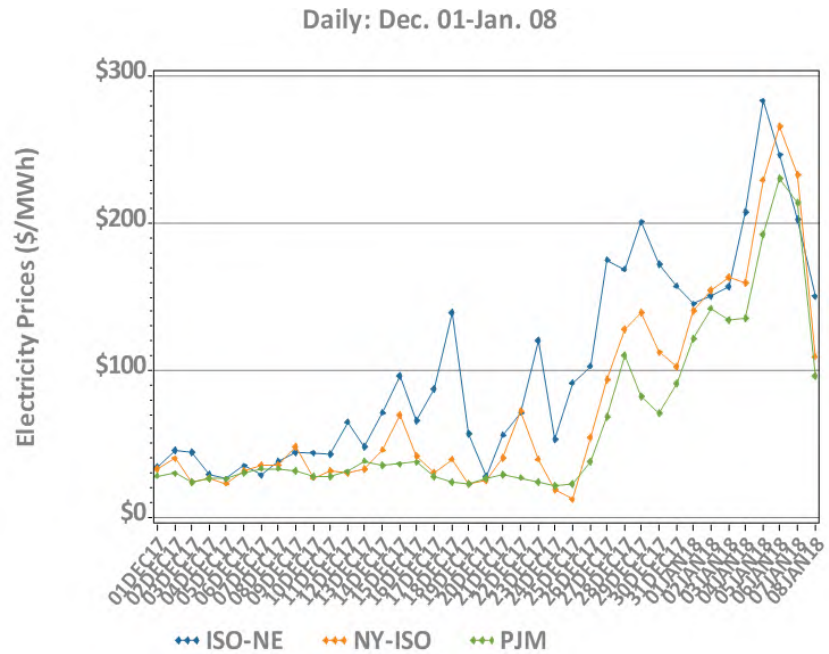


Note: Data for January 5-8 reflect preliminary settlements

New England, NY, and PJM Hourly Average Real Time Prices by Month



*Note: Hourly average prices are shown.



*Note: Hourly average prices are shown.

Summary and Next Steps

- The system operated reliably through the extended cold weather event and was relying heavily on oil to meet load and reserves
- The ISO is working with individual asset owners to understand their replenishment logistics and outstanding emissions concerns
- It is essential that fuel inventories are sufficiently replenished for the rest of the winter period
- The ISO will further assess the performance of the market during the cold weather event, and looks forward to discussing these topics with stakeholders

