



# Cold Weather Operations

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*December 24, 2017 – January 8, 2018*

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EXECUTIVE VICE PRESIDENT AND CHIEF OPERATING OFFICER



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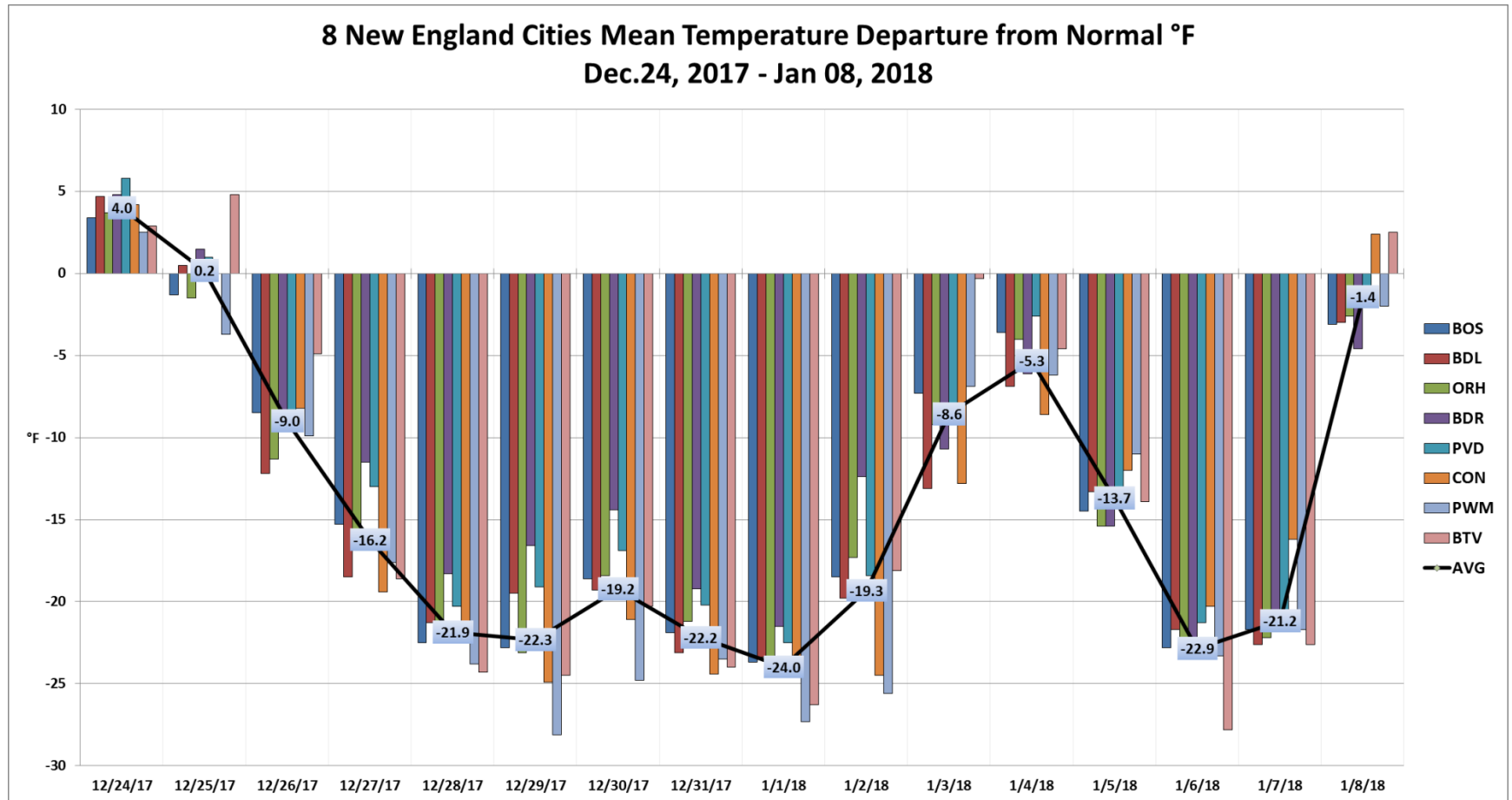
# COLD WEATHER CONDITIONS

# Arctic Outbreak 2017-18

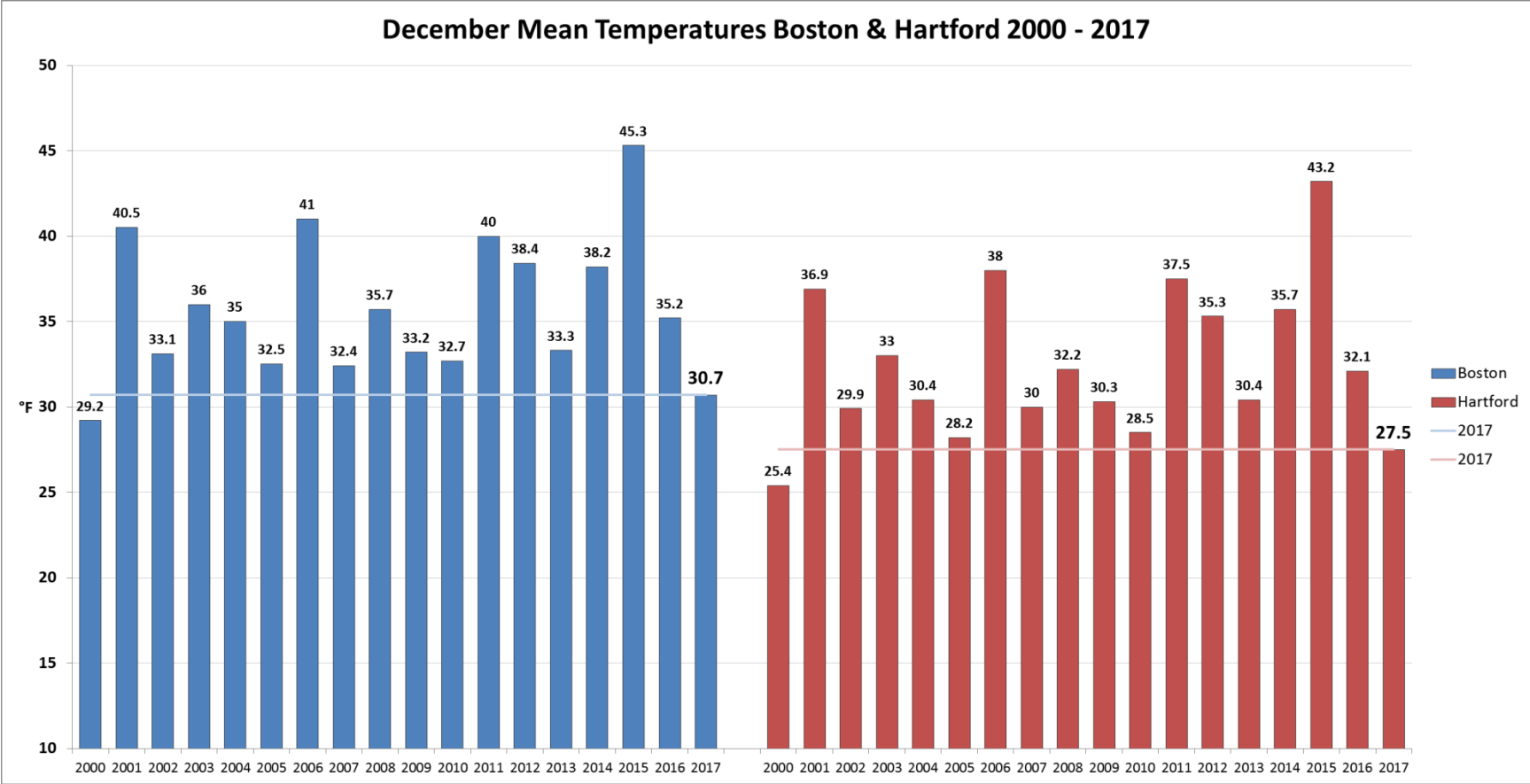
- New England was gripped by a cold weather stretch for an extended duration between December 25 and January 8
- All major cities in New England had average temperatures below normal for at least 13 consecutive days, of which 10 days averaged more than 10°F below normal
- In Boston, for example, an Arctic 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.



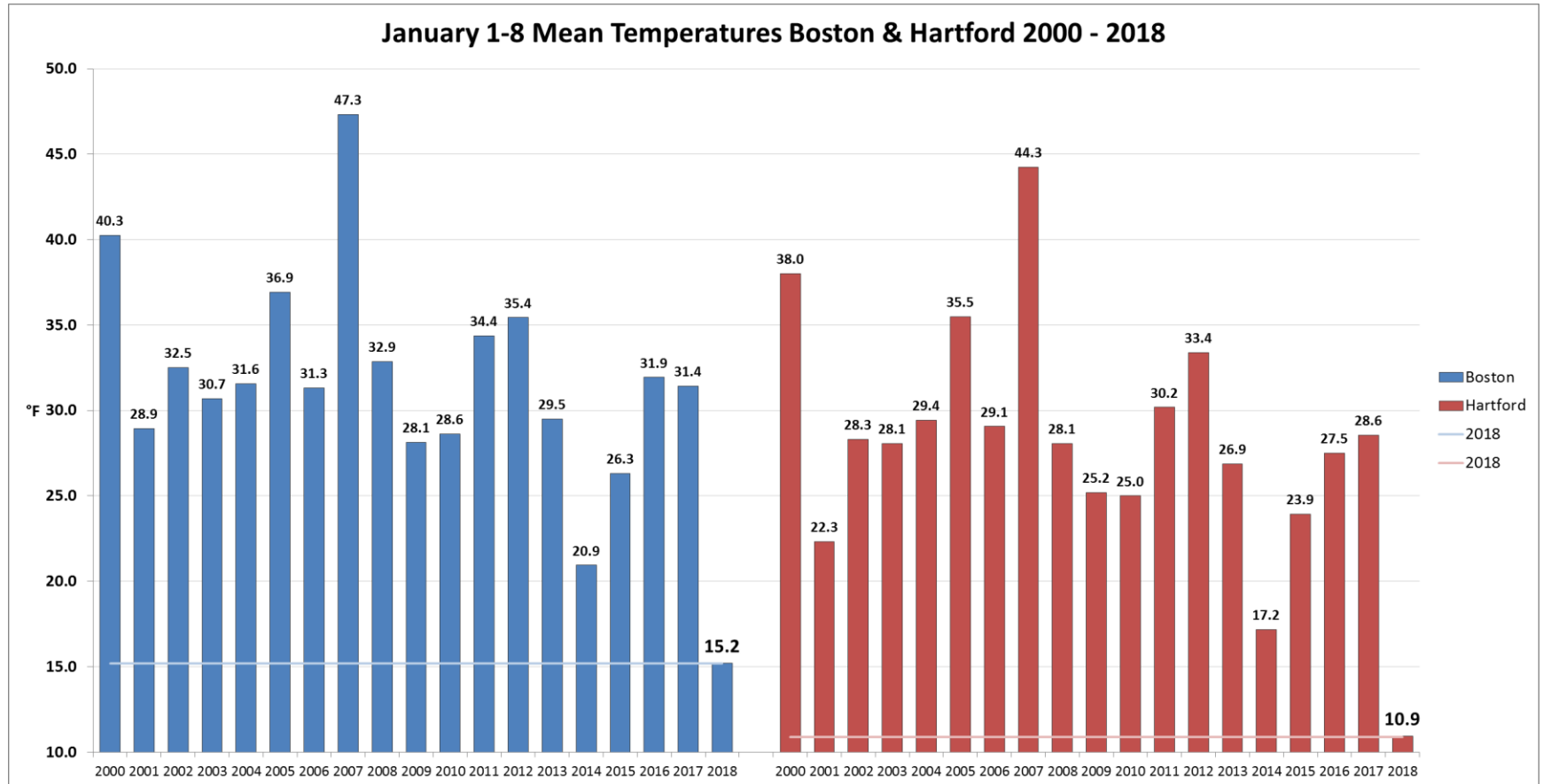
# Mean Temperatures Depart from Normal



# Coldest December Mean Temps since at least 2000

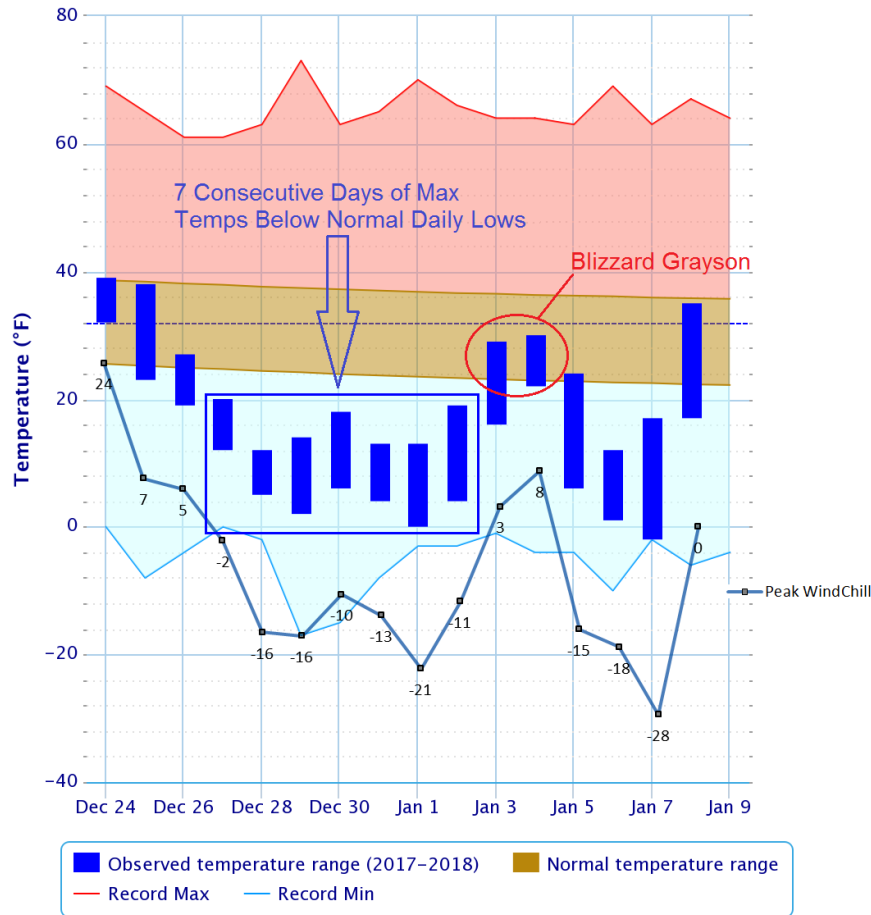


# Coldest January 1-8 since at least 2000



# Arctic Outbreak 2017-18 Boston Temperatures

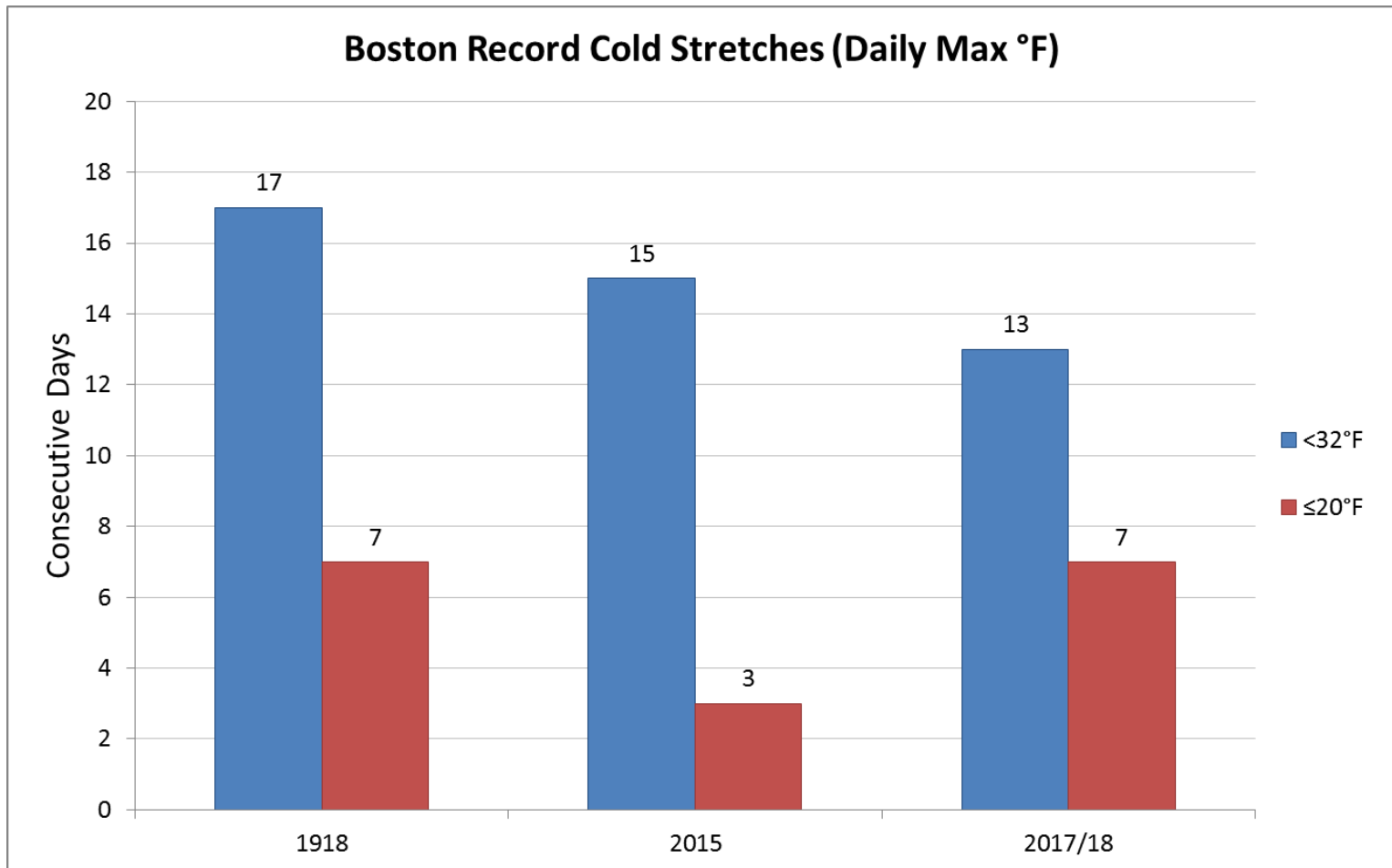
Daily Temperature Data – Boston, MA  
December 24, 2017 - January 08, 2018



- 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

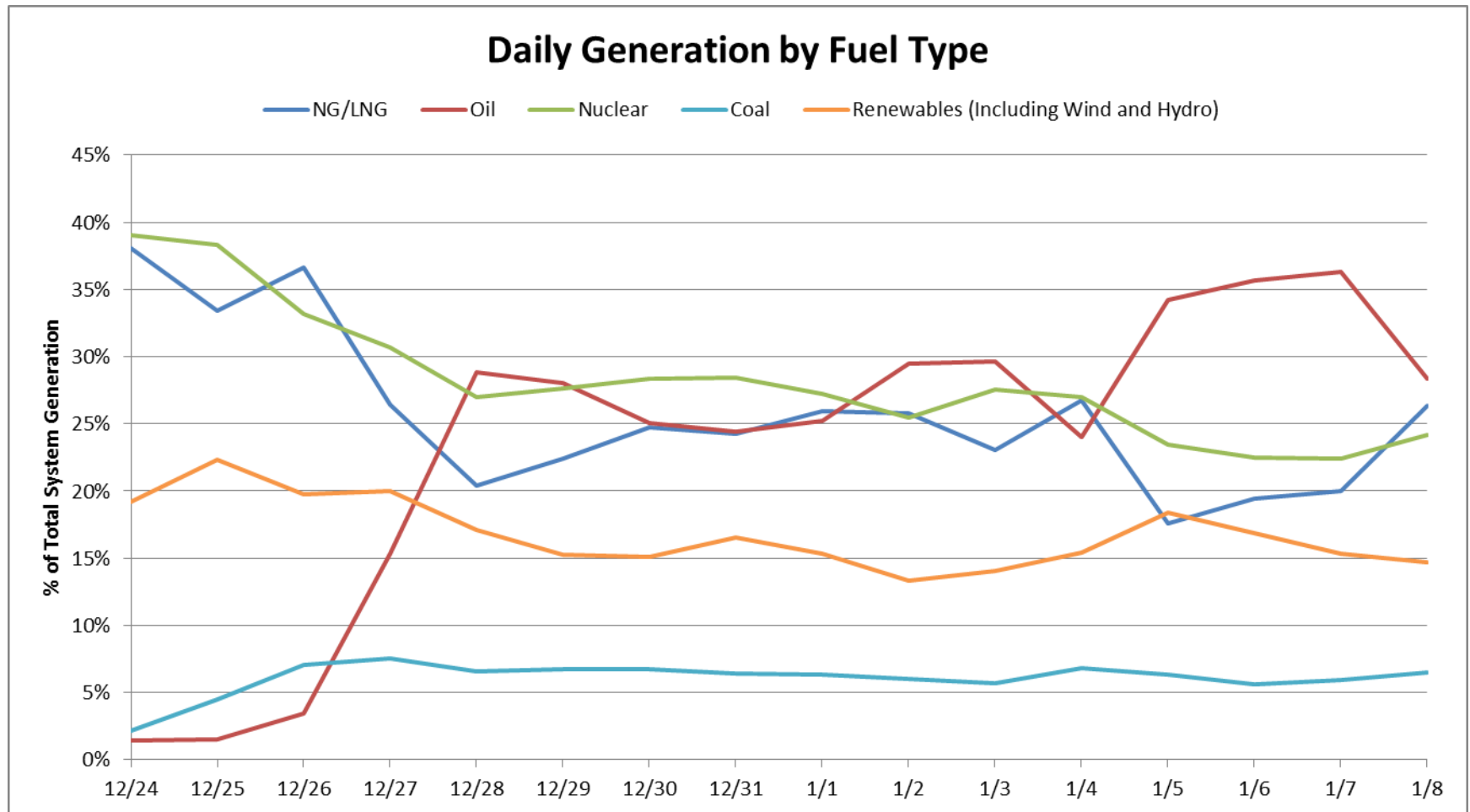


# New England Fuel Mixture

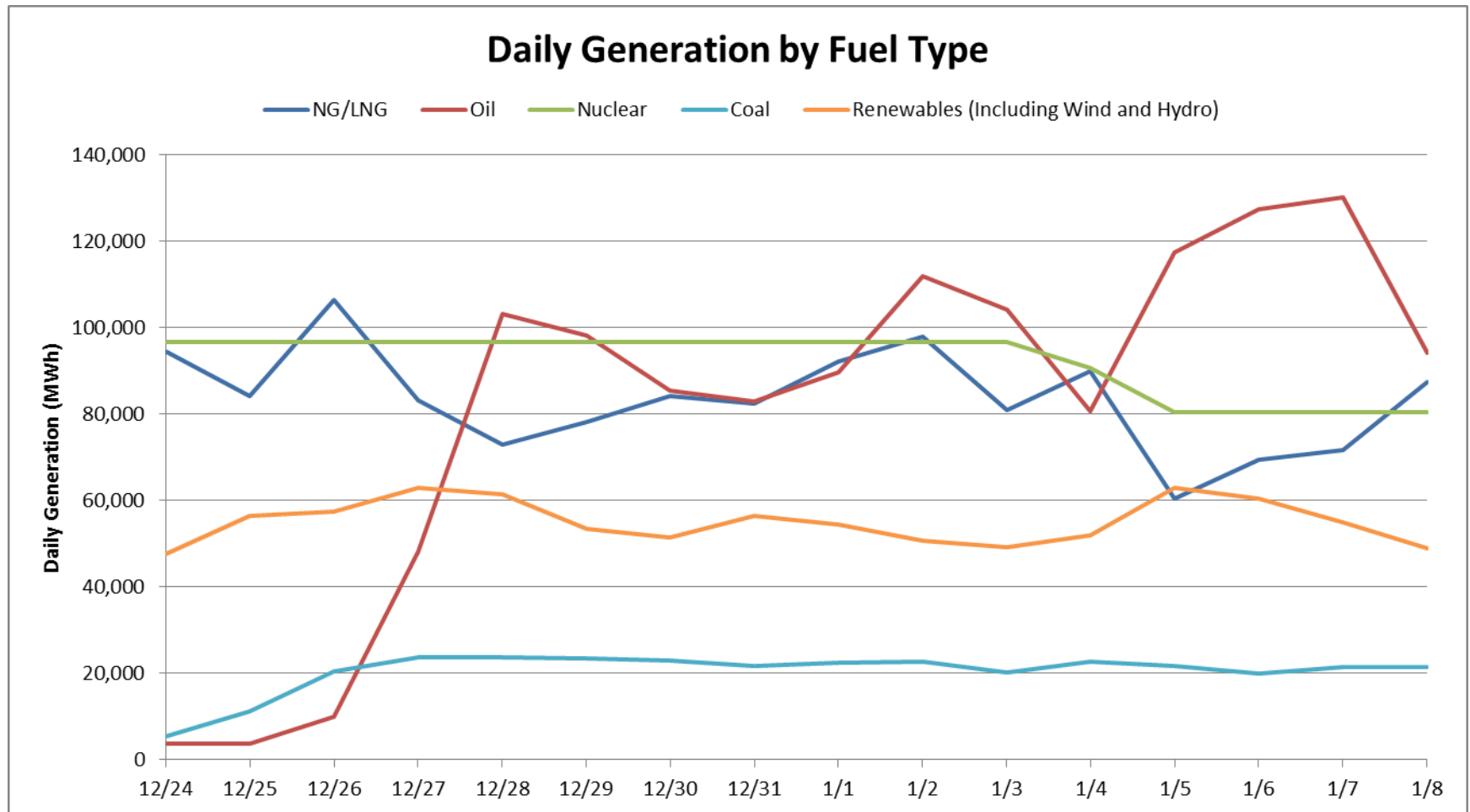
- Overall, there was significantly higher than normal use of oil
  - Coal use also increased over normal use
- Gas and Oil fuel price inversion led to oil being in economic merit and base loaded
- As gas became uneconomic, the entire season's oil supply rapidly depleted



# Daily Generation by Fuel Type (Percent of total)

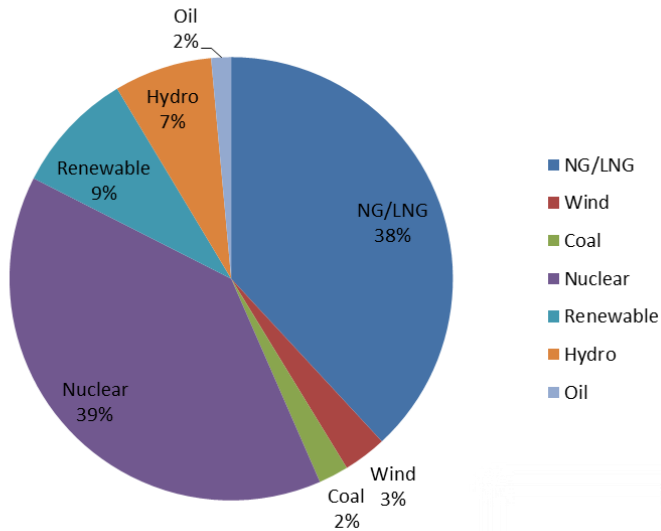


# Daily Generation by Fuel Type (MWh)

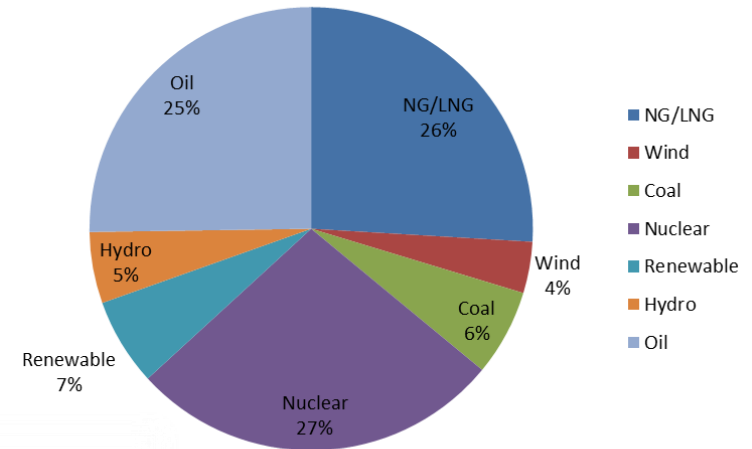


# Shifting Generation Mix Before and During the Cold Snap

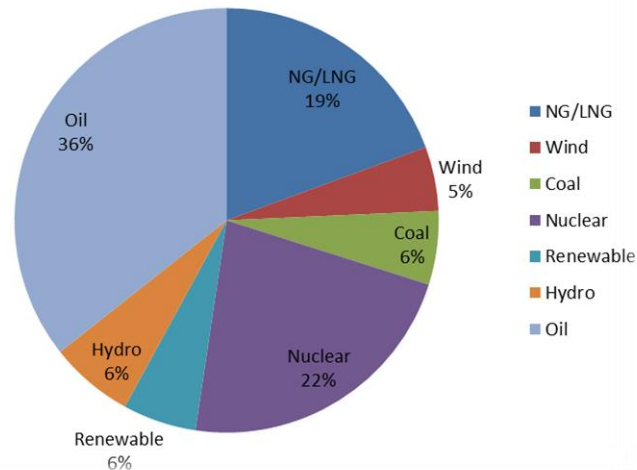
Fuel Diversity - 12/24/17



Fuel Diversity - 1/1/18



Fuel Diversity - 1/6/18



# COLD WEATHER OIL USAGE



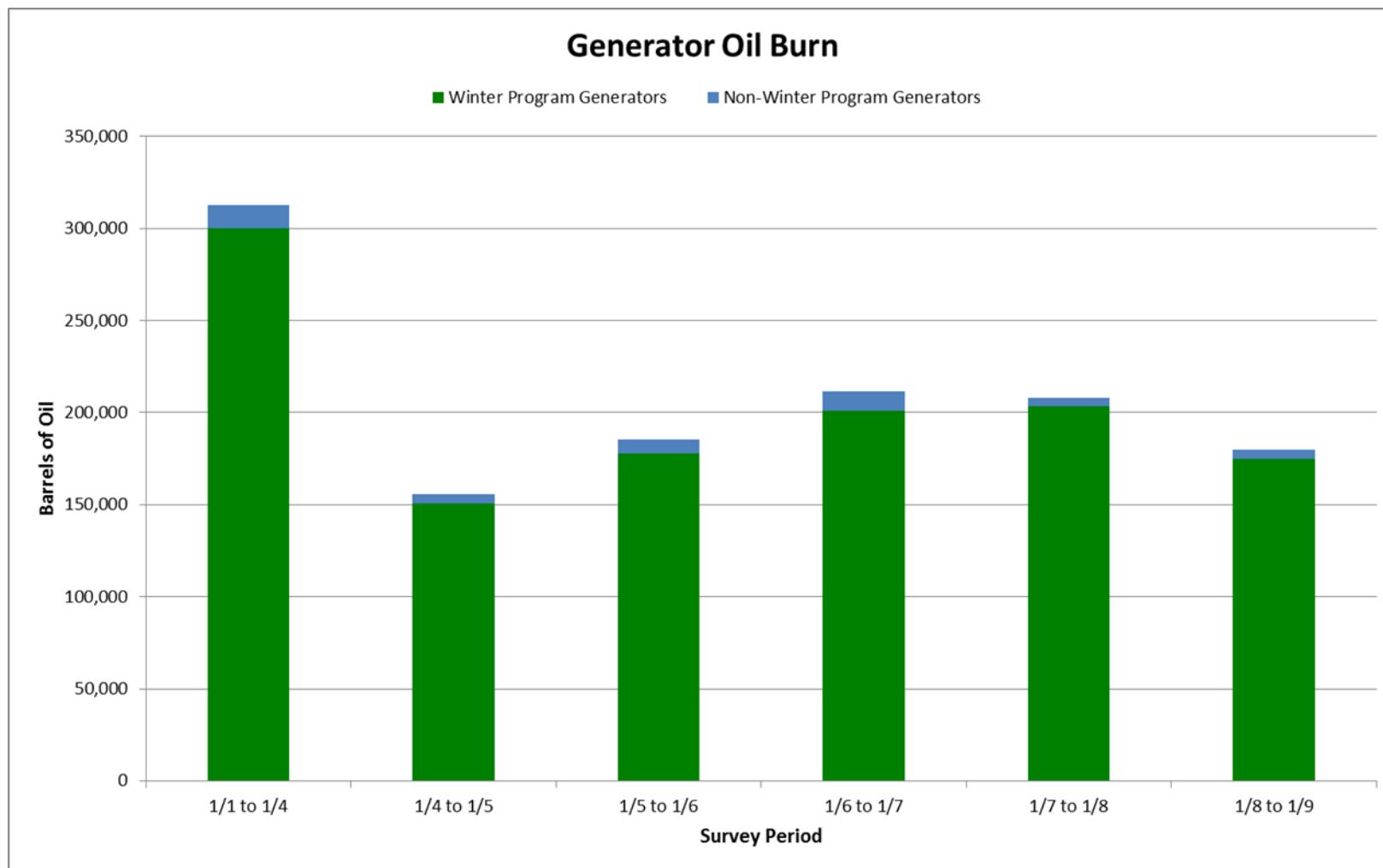
# Winter Reliability Program vs Actual Oil Burn

- 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

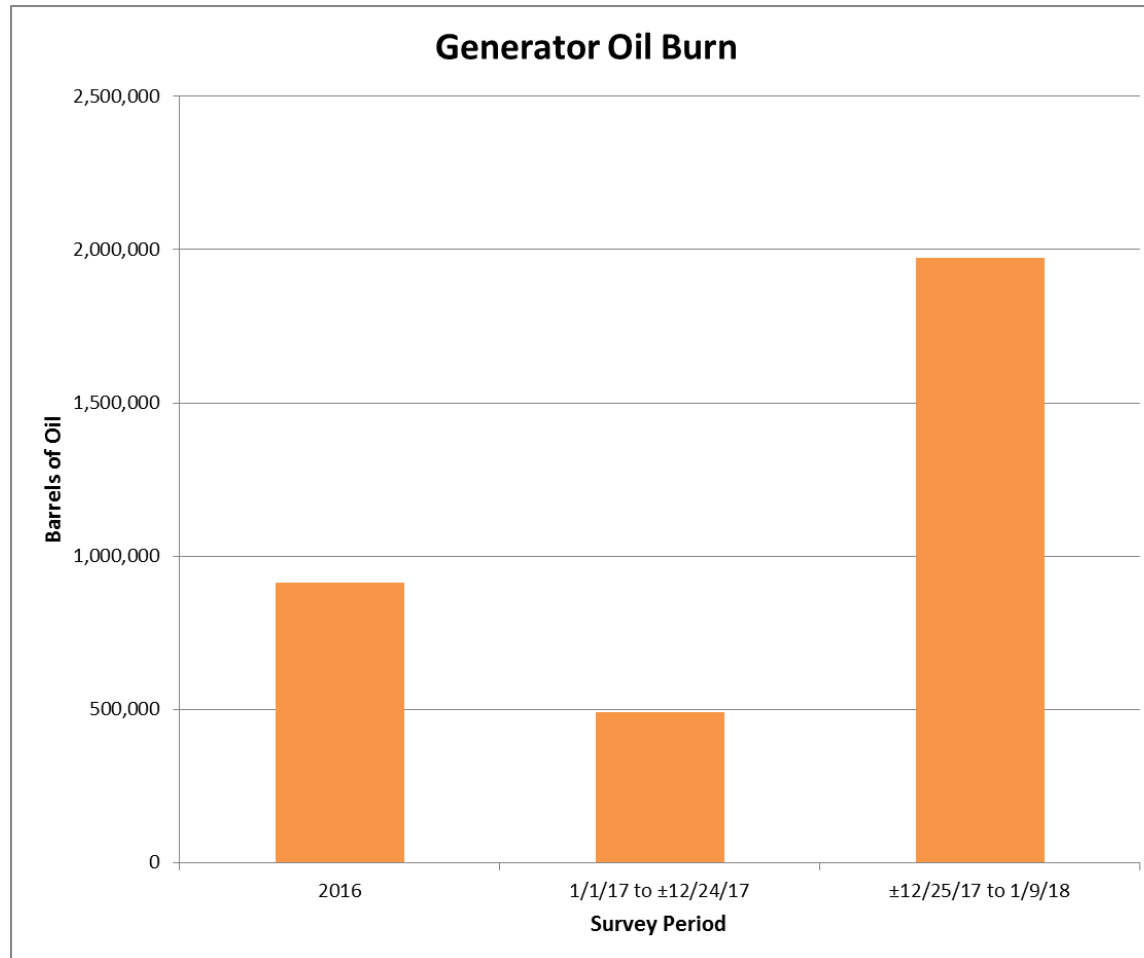




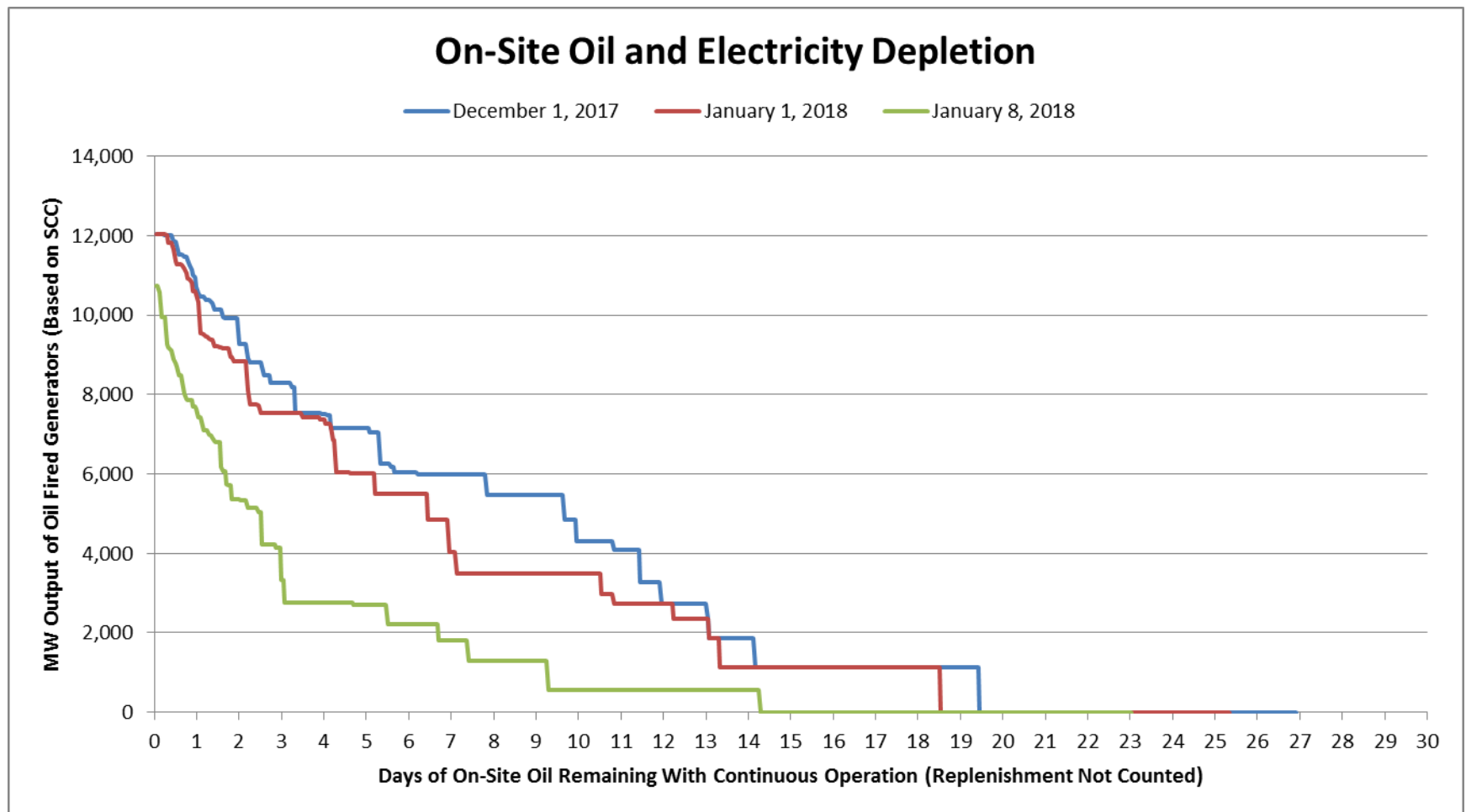
# Generator Oil Burn – January 2018



# Generator Oil Burn – Yearly Comparison

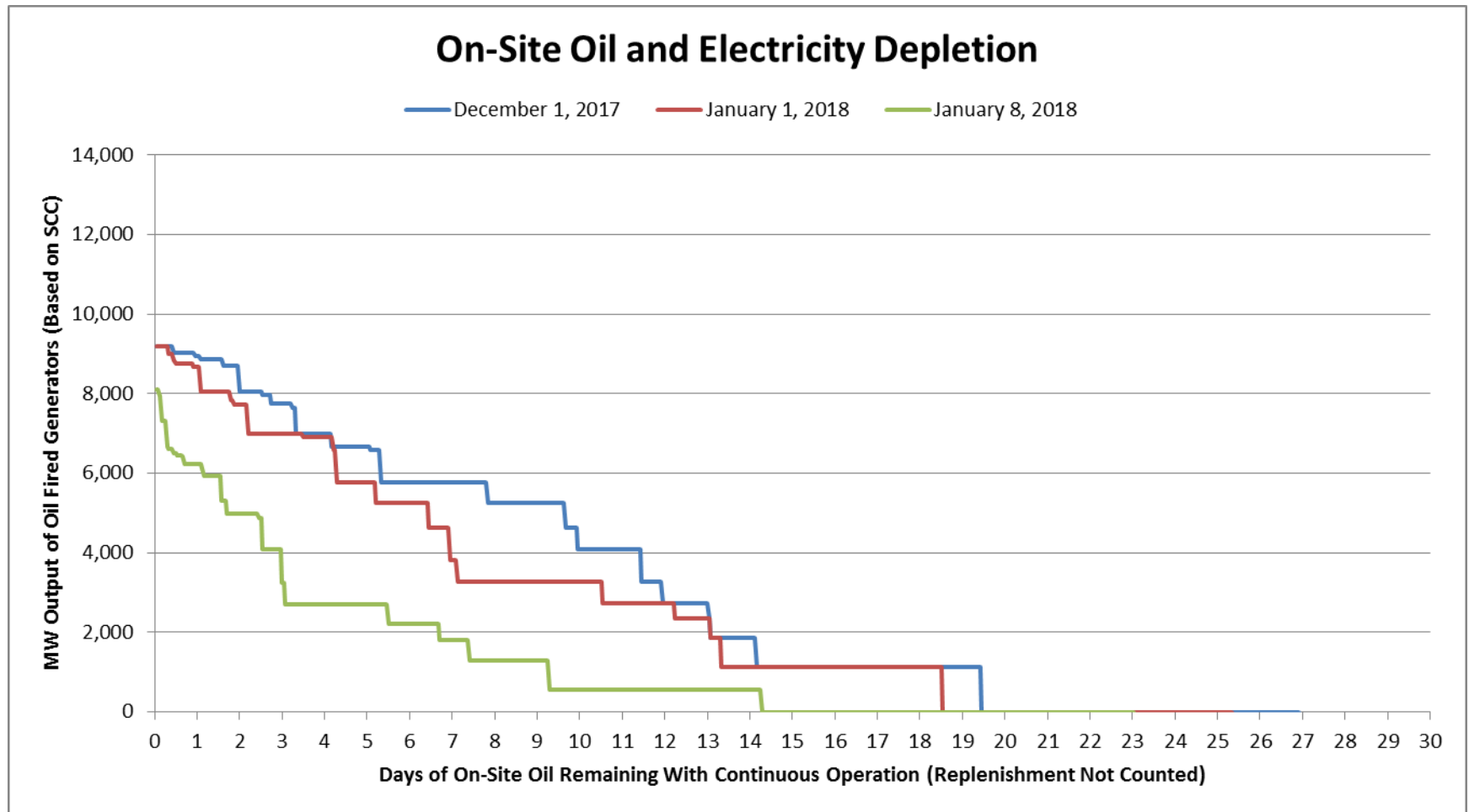


# On-Site Oil and Electricity Depletion



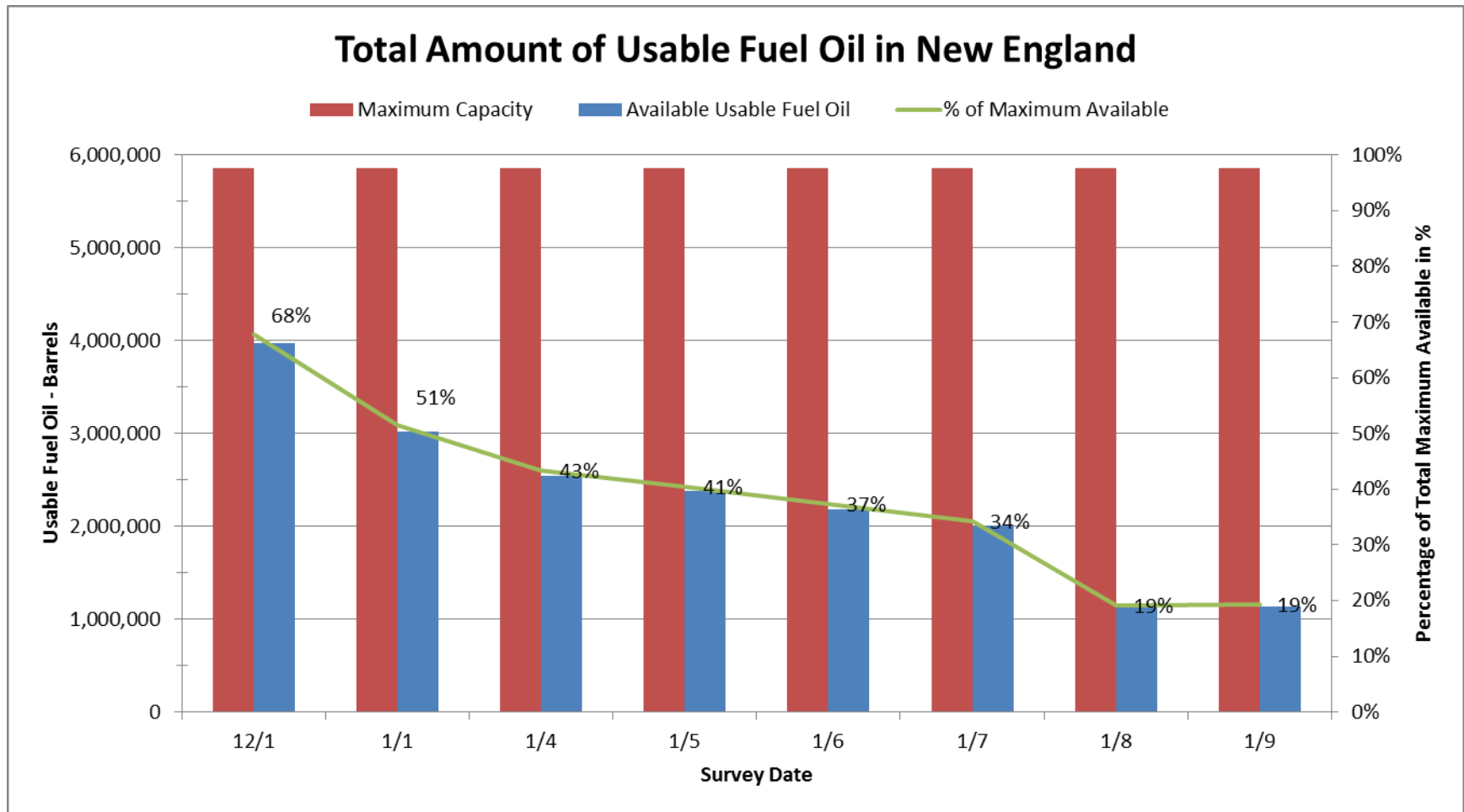
This chart is the ISO's best approximation of usable oil discounting for unit outages, reductions, or emissions

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



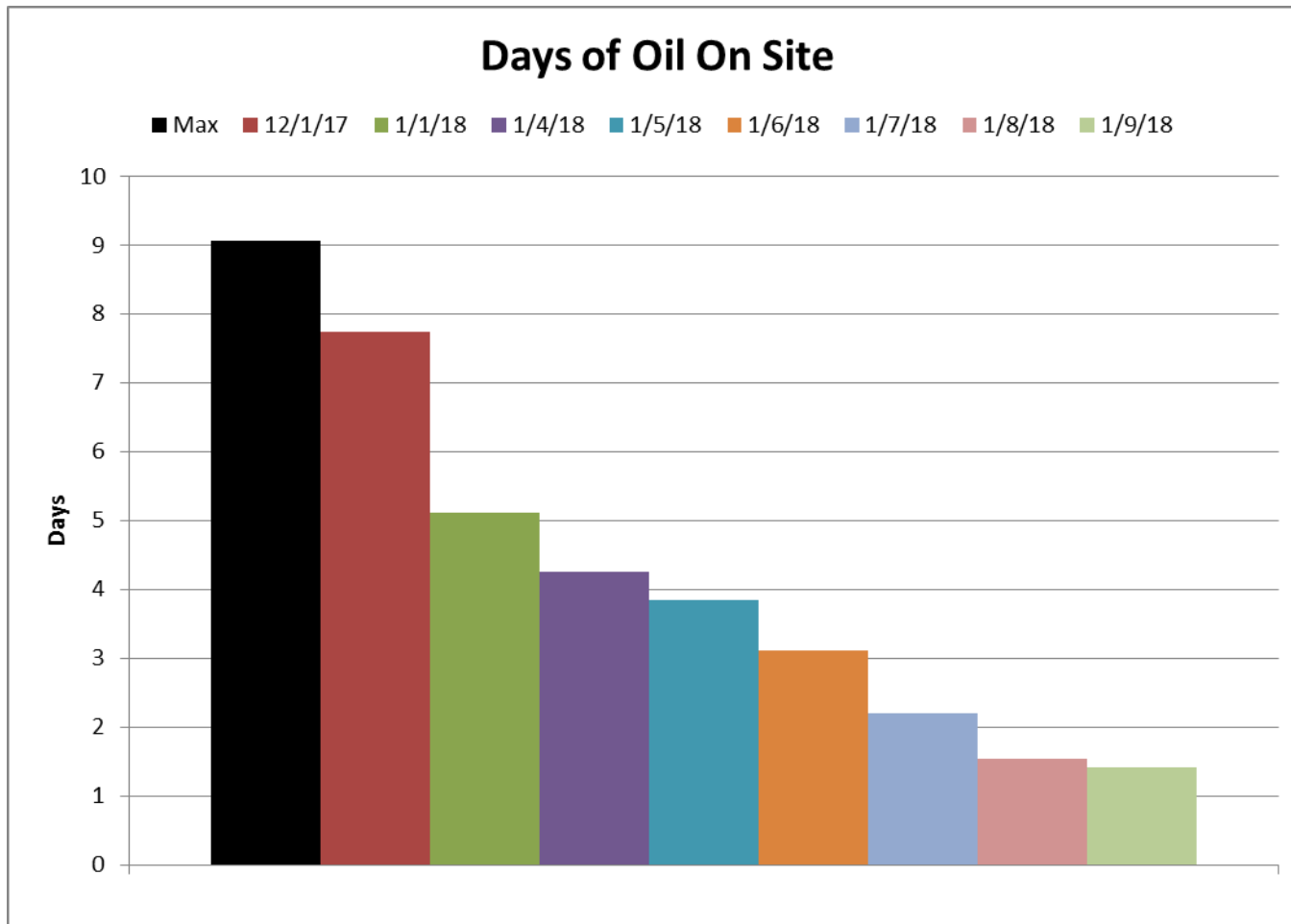
This chart is the ISO's best approximation of usable oil discounting for unit outages, reductions, or emissions

# 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 5<sup>th</sup> after interruption due to Winter Storm Grayson on January 4<sup>th</sup>
  - 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

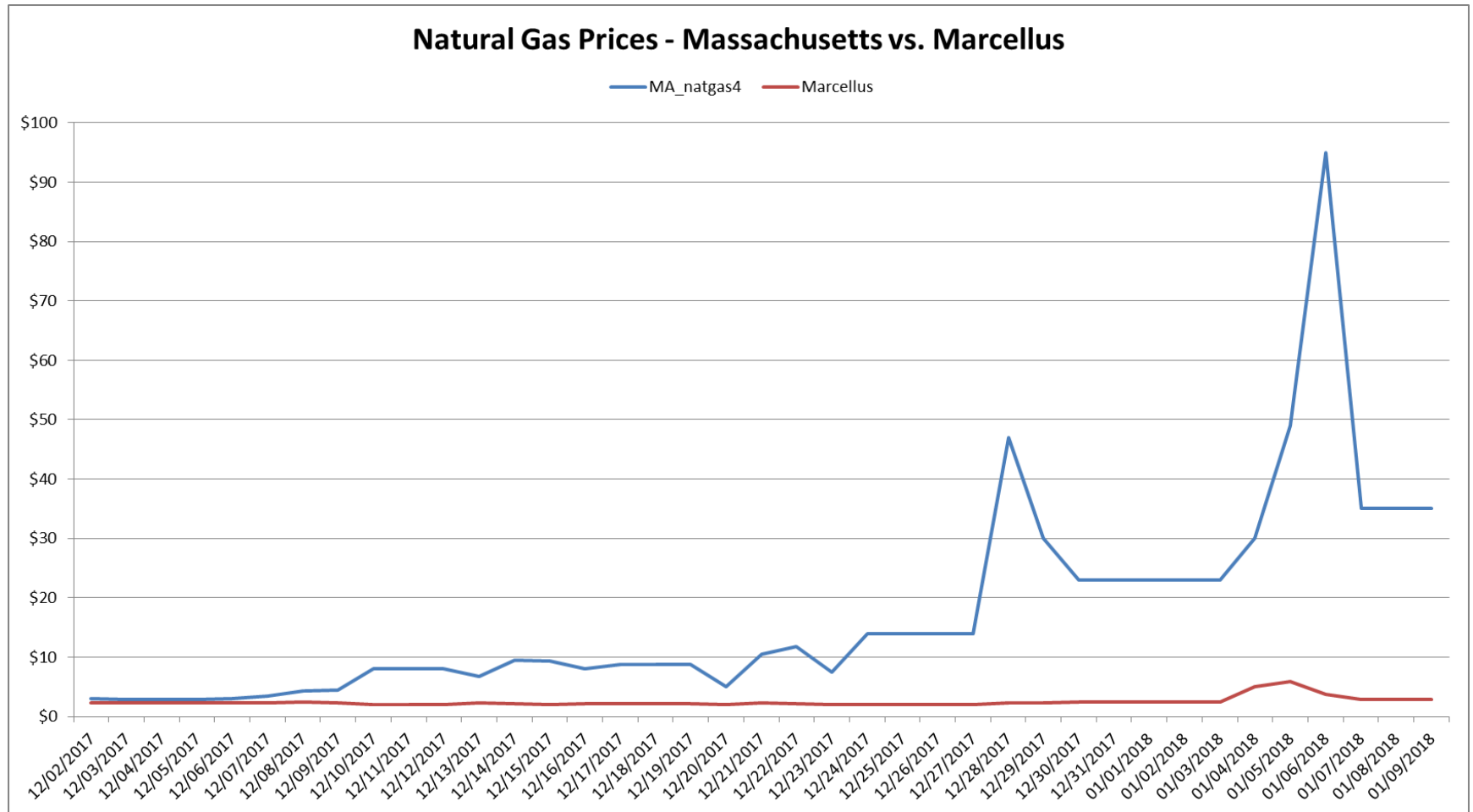
- On Friday afternoon, January 5, Governor Baker signed a revised declaration of emergency that provides relief for fuel deliveries to electric generating facilities until January 19
  - The original declaration, dated December 28, covered fuel deliveries for heating but not electric generating facilities



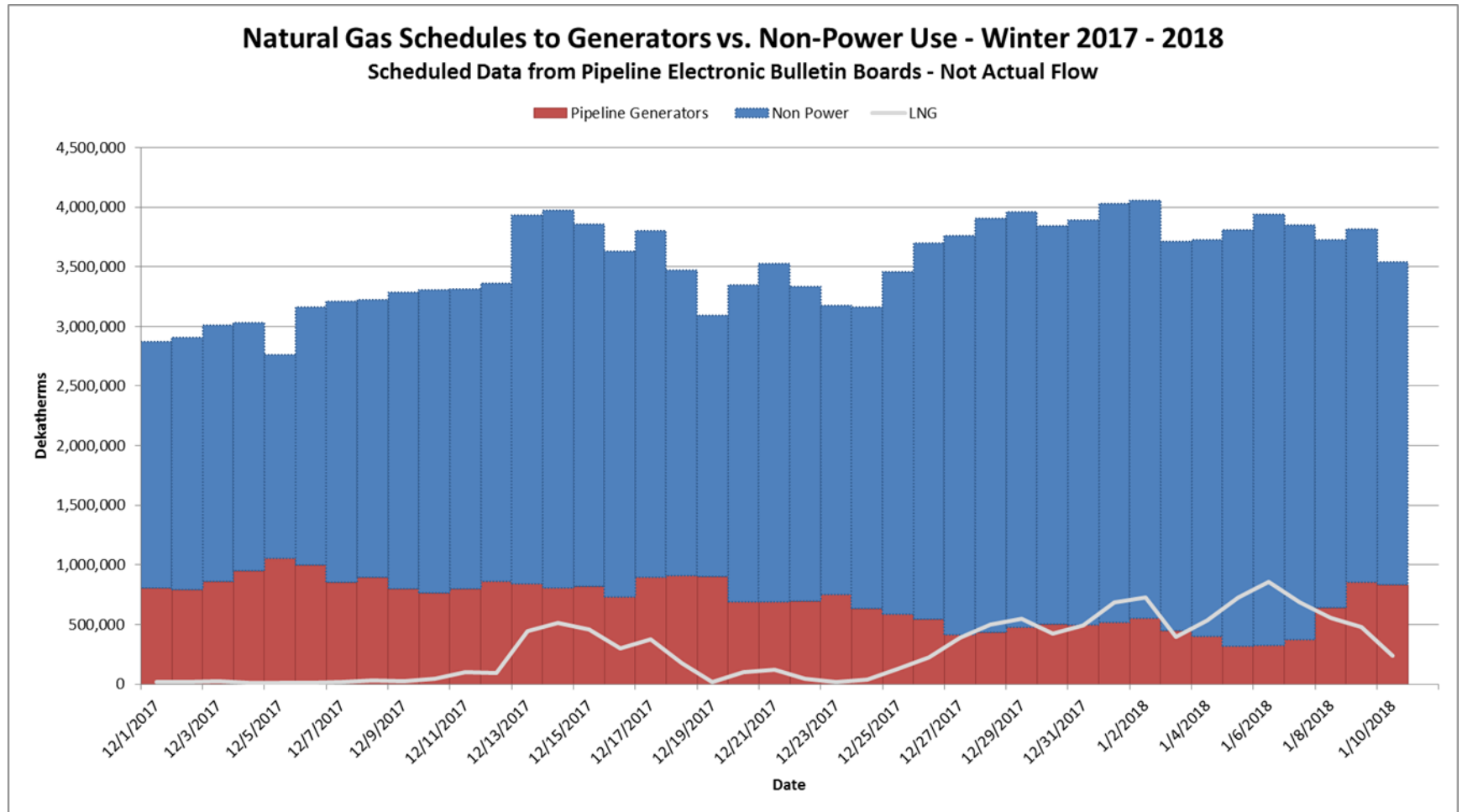
# Fuel Surveys

- 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

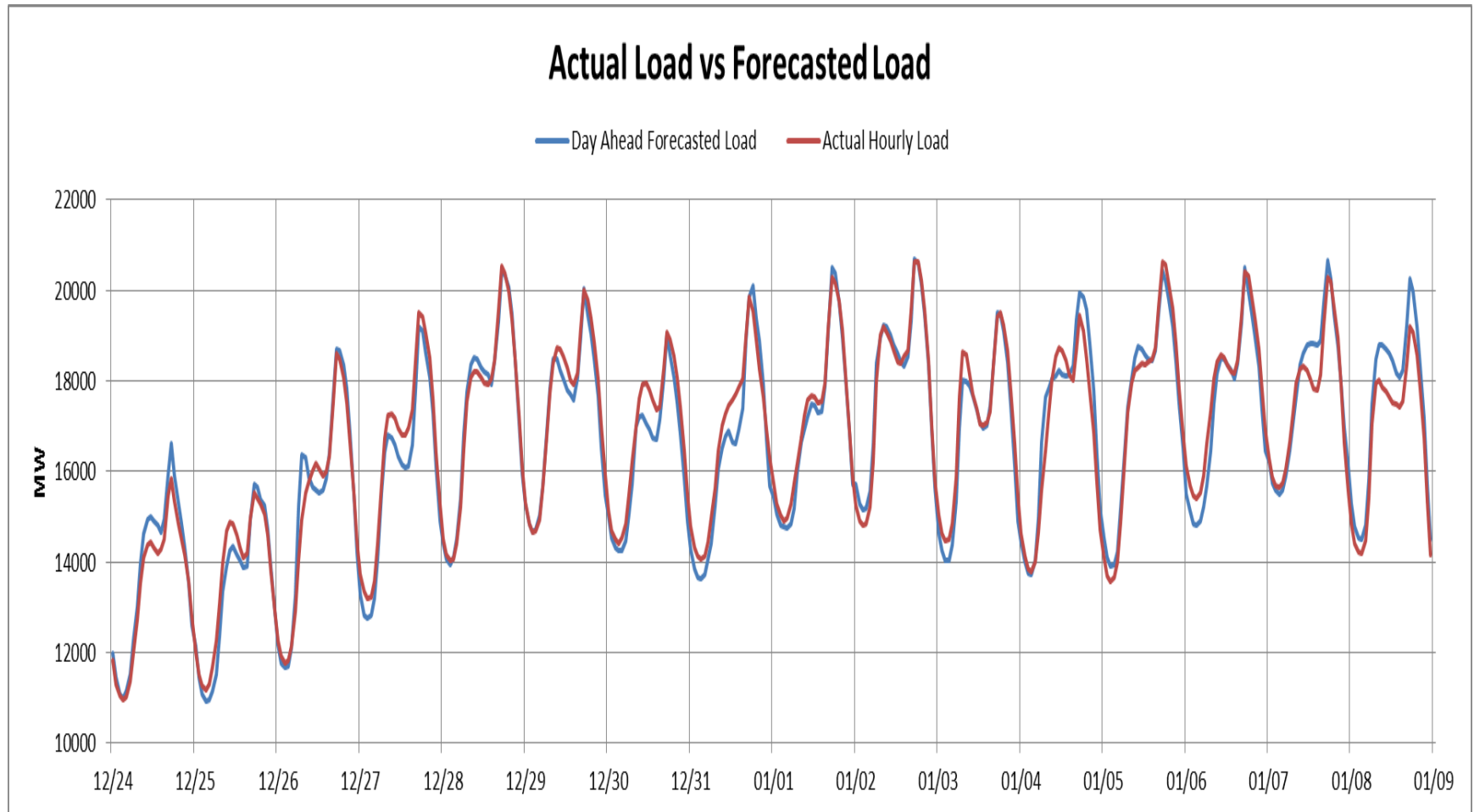


# System Operations: Communications, cont.

- 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



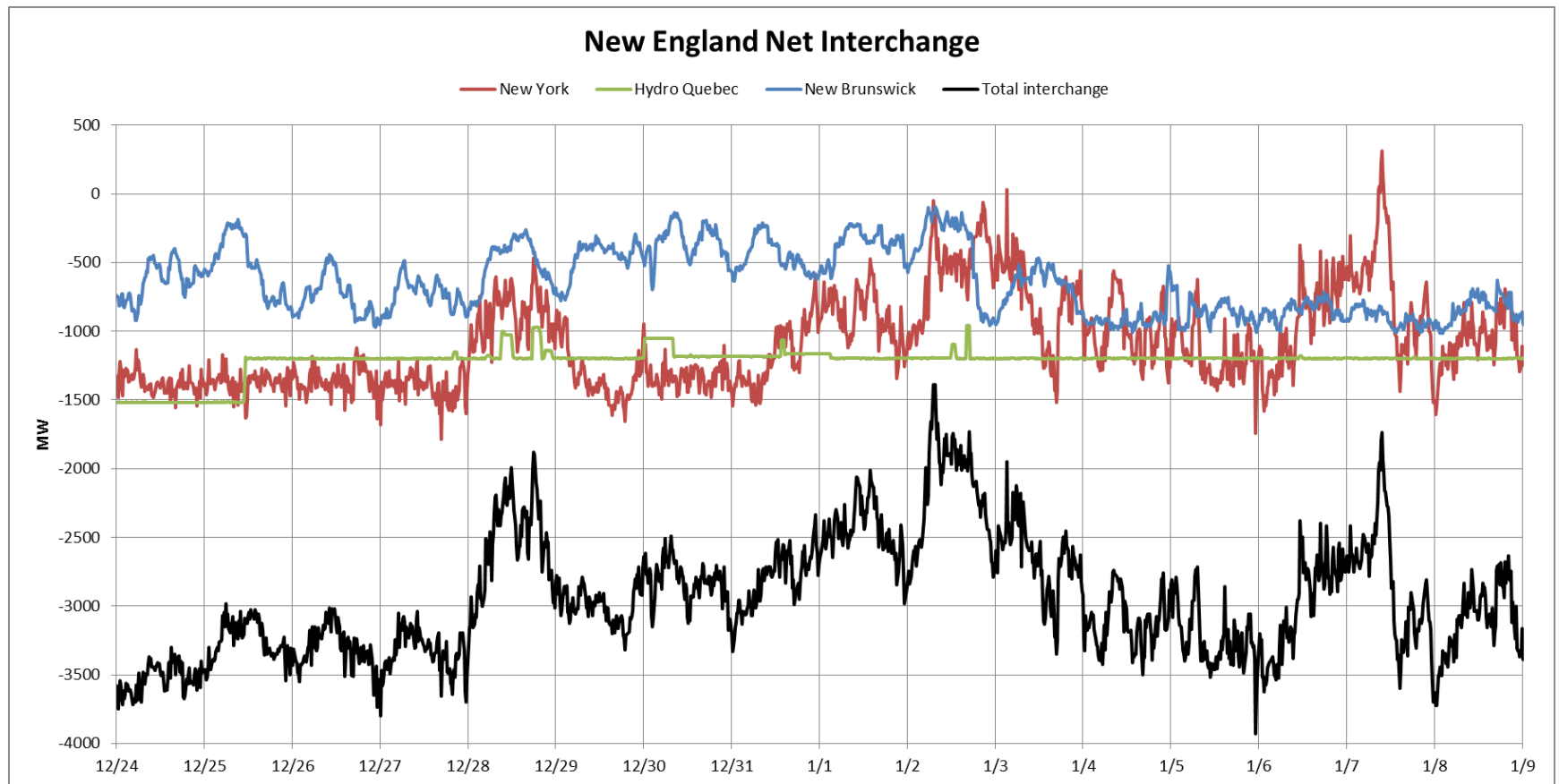


# System Operations: Interchange

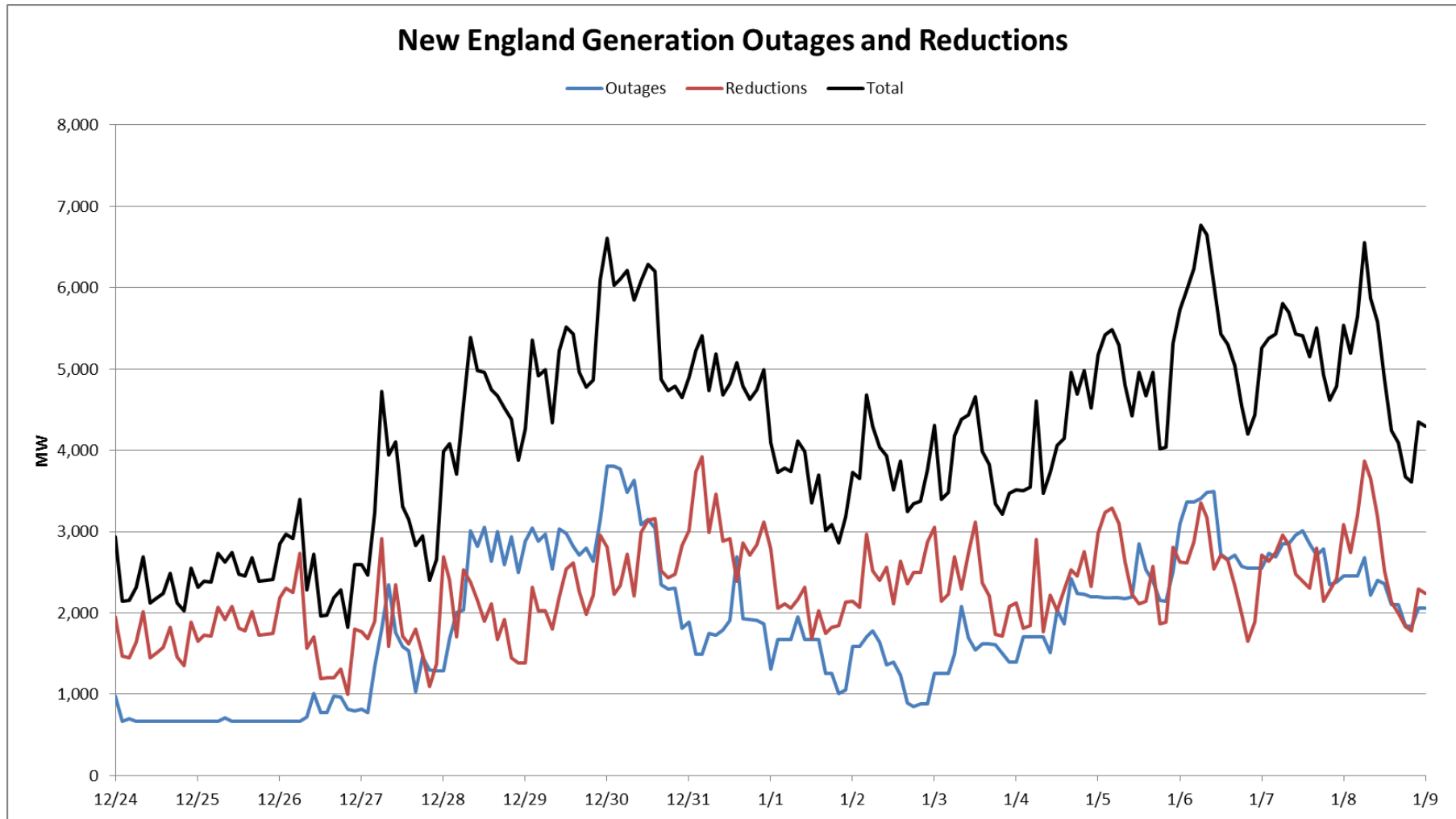
- Increase in Scheduling Limit with NYISO
  - At 16:00 on 1/3/18, the scheduling limit on the NY A.C. ties was increased from 1,400 to 1,600MW
  - The increased limit was made possible by the cold conditions which helped to improve thermal transfer capability



# 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

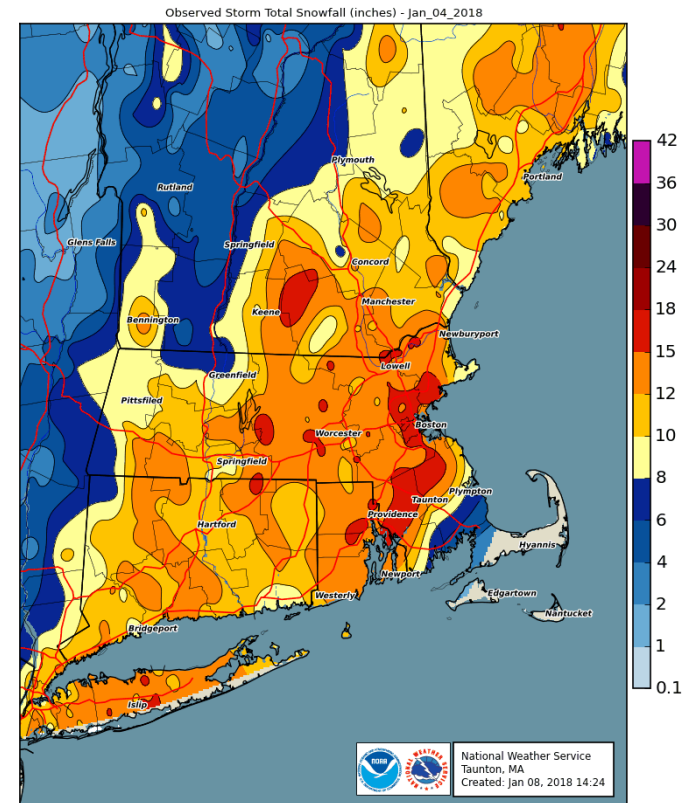


# PV AND WIND OUTPUT

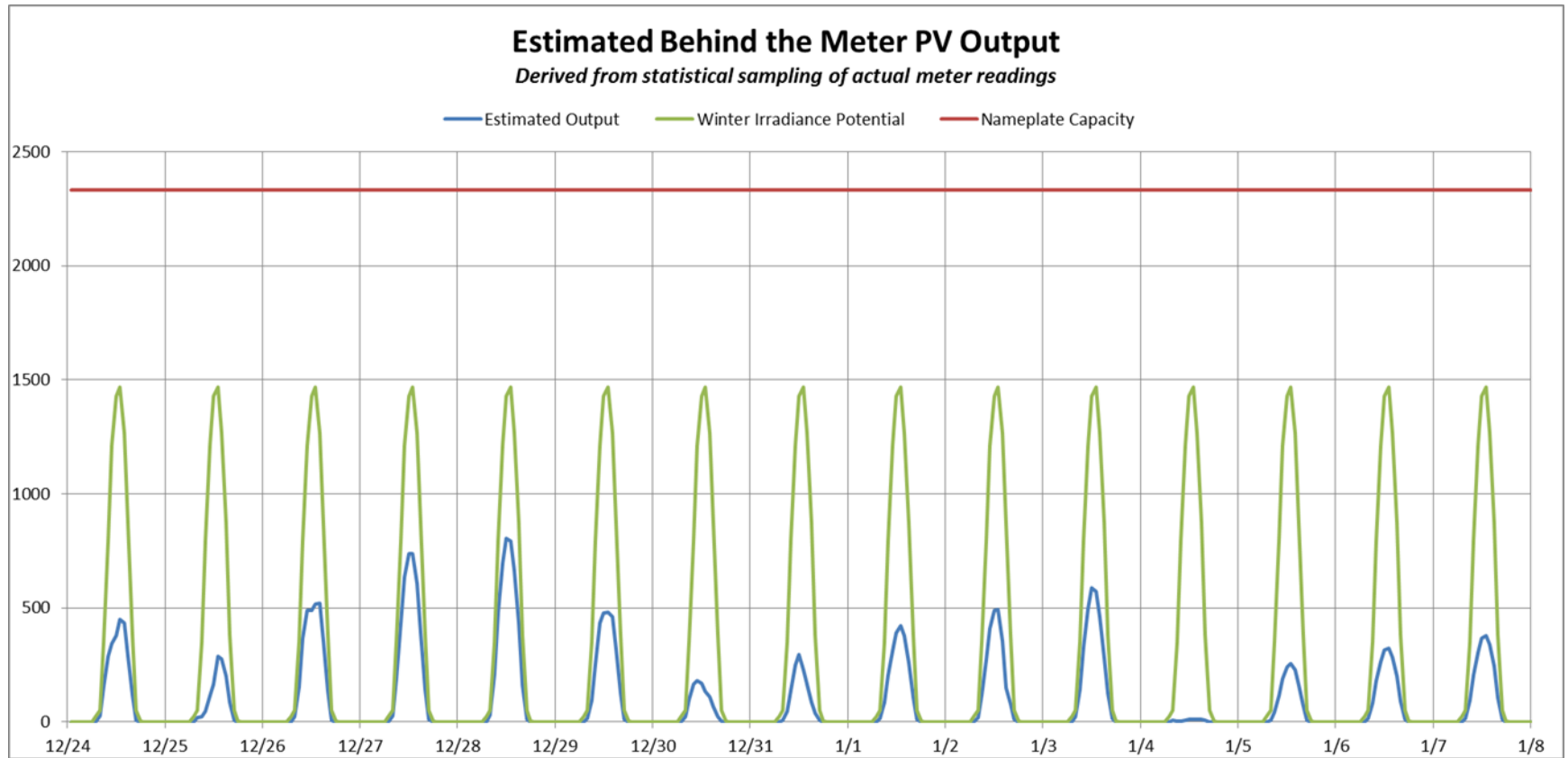


# Impact of Snowfall on Energy from PV

- 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

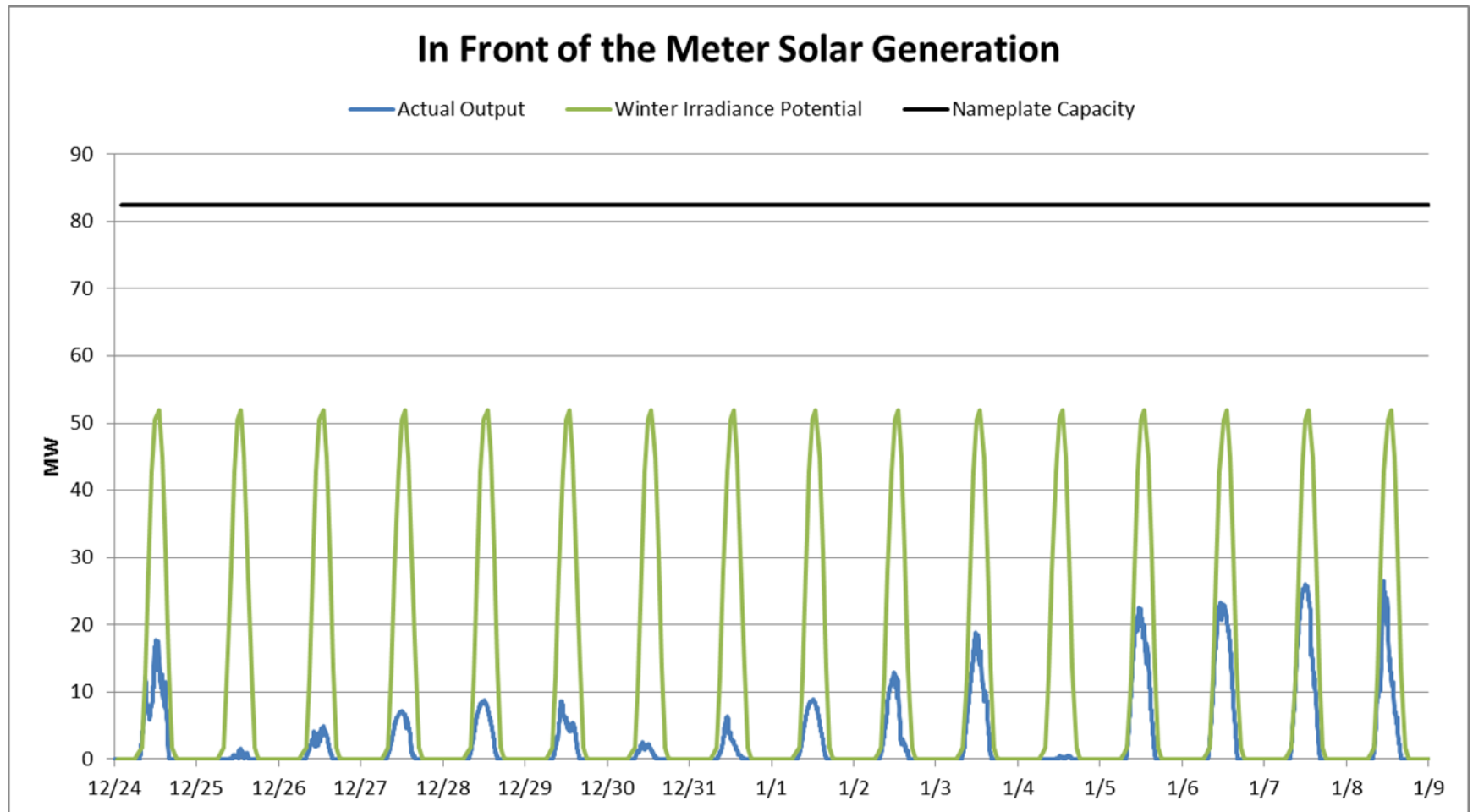


# PV Generation – Behind the Meter

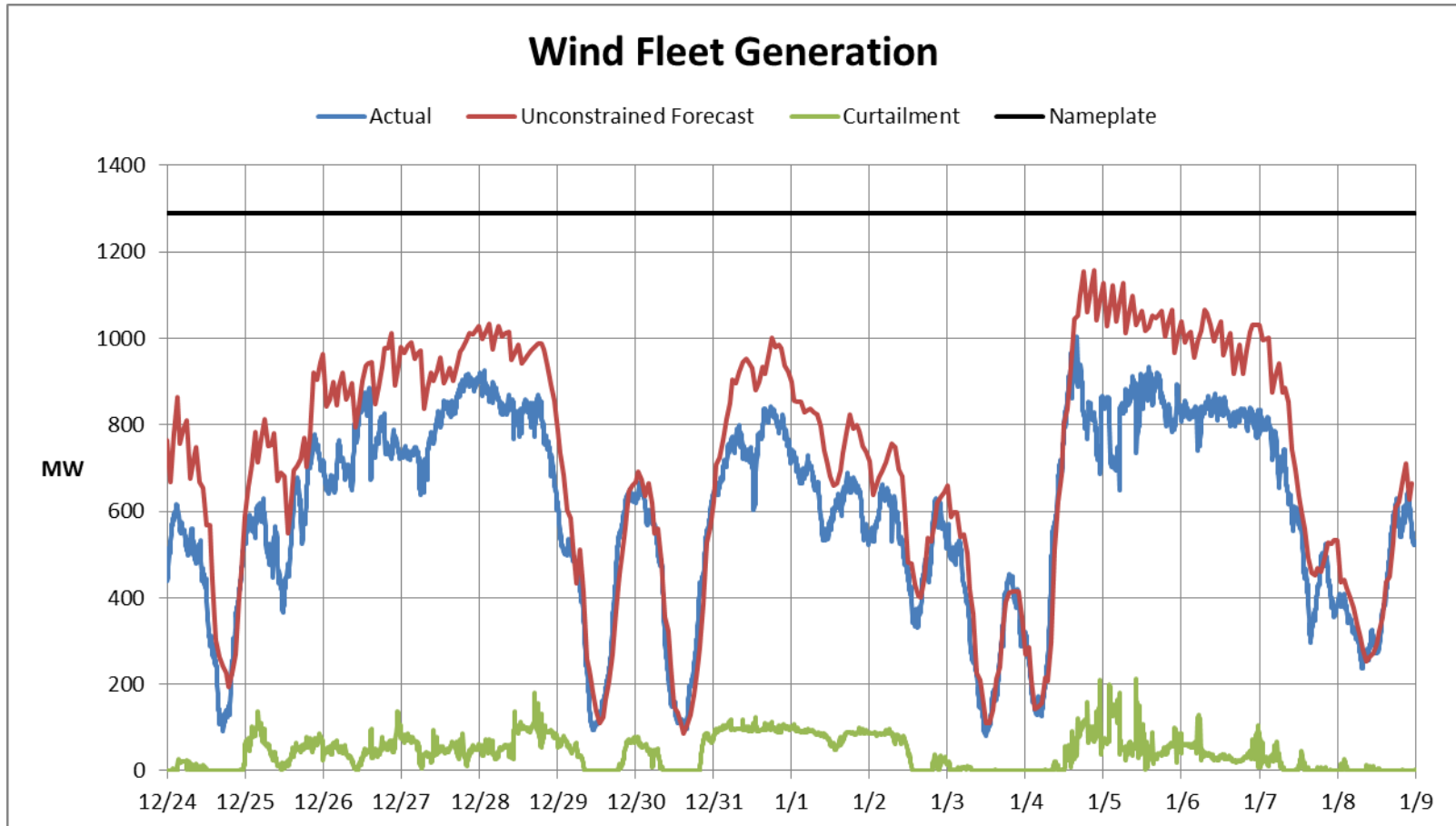




# PV Generation – In Front of the Meter



# Wind Generation

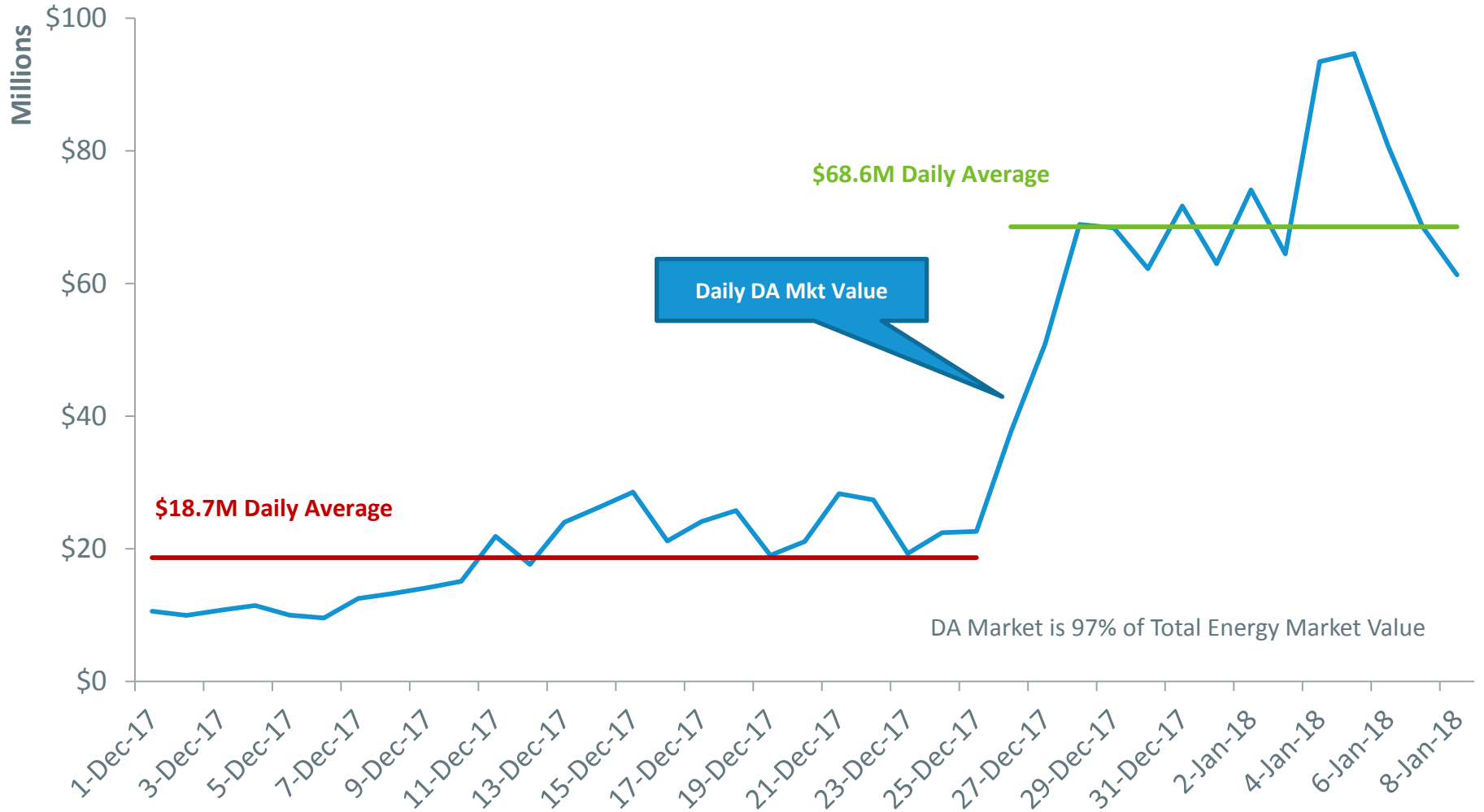


After 00:01 on 1/5/18, several wind plants in the region experienced intermittent high speed wind cutout events. Curtailments are due to transmission congestion.

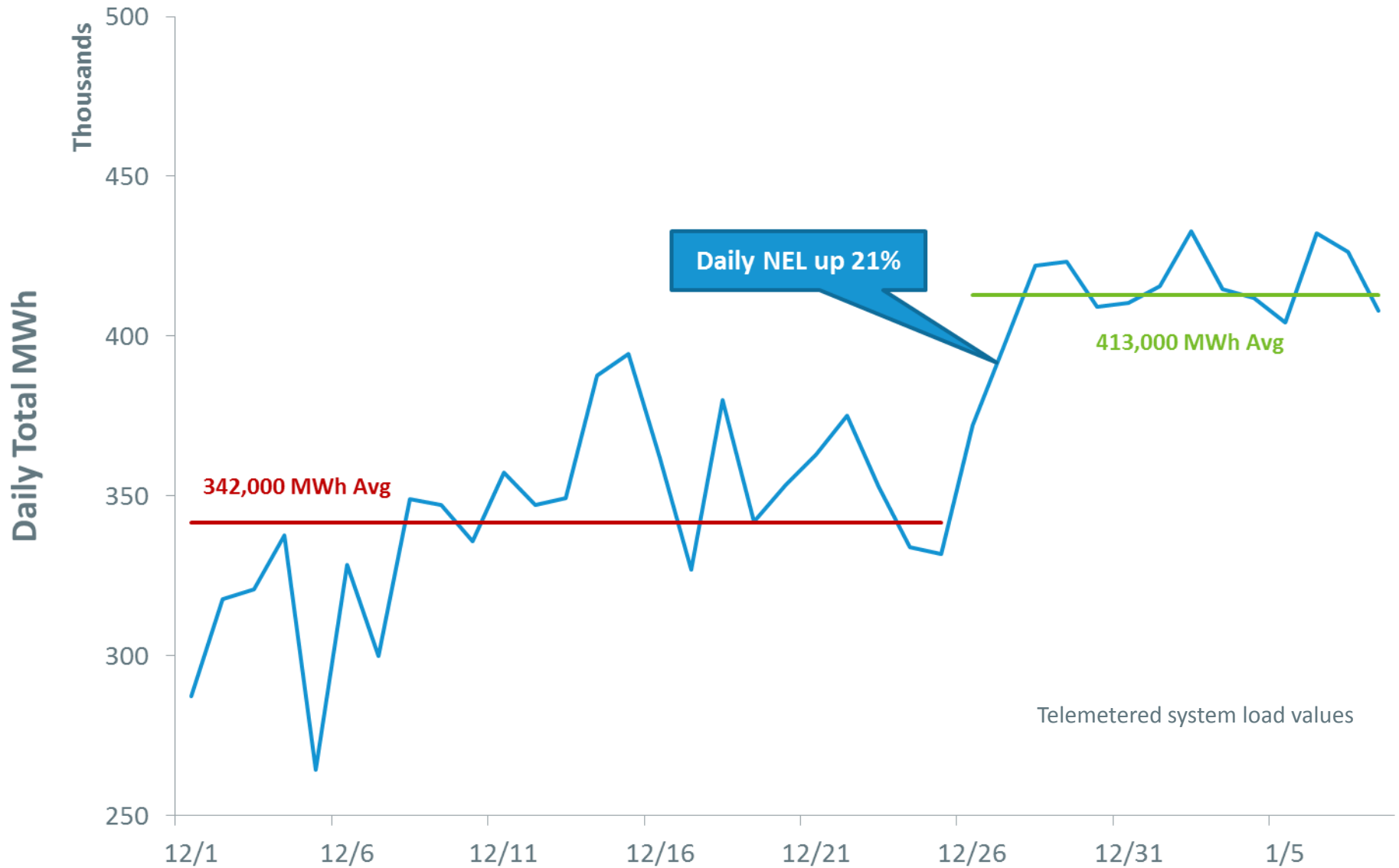
# MARKET DATA



# Daily DA Market Cost Before and During the Cold Snap

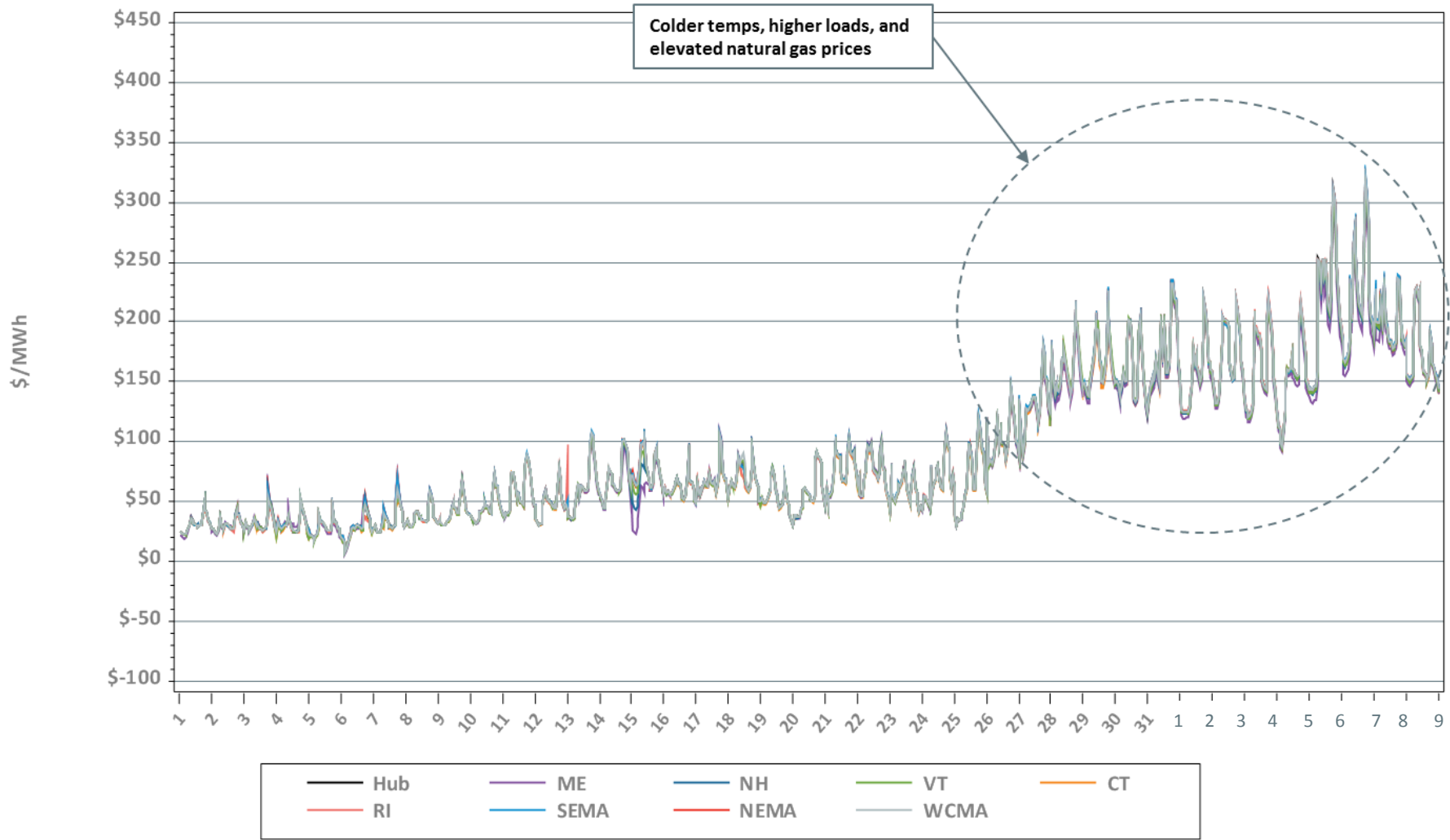


# Daily System Load Increased 21% after Christmas



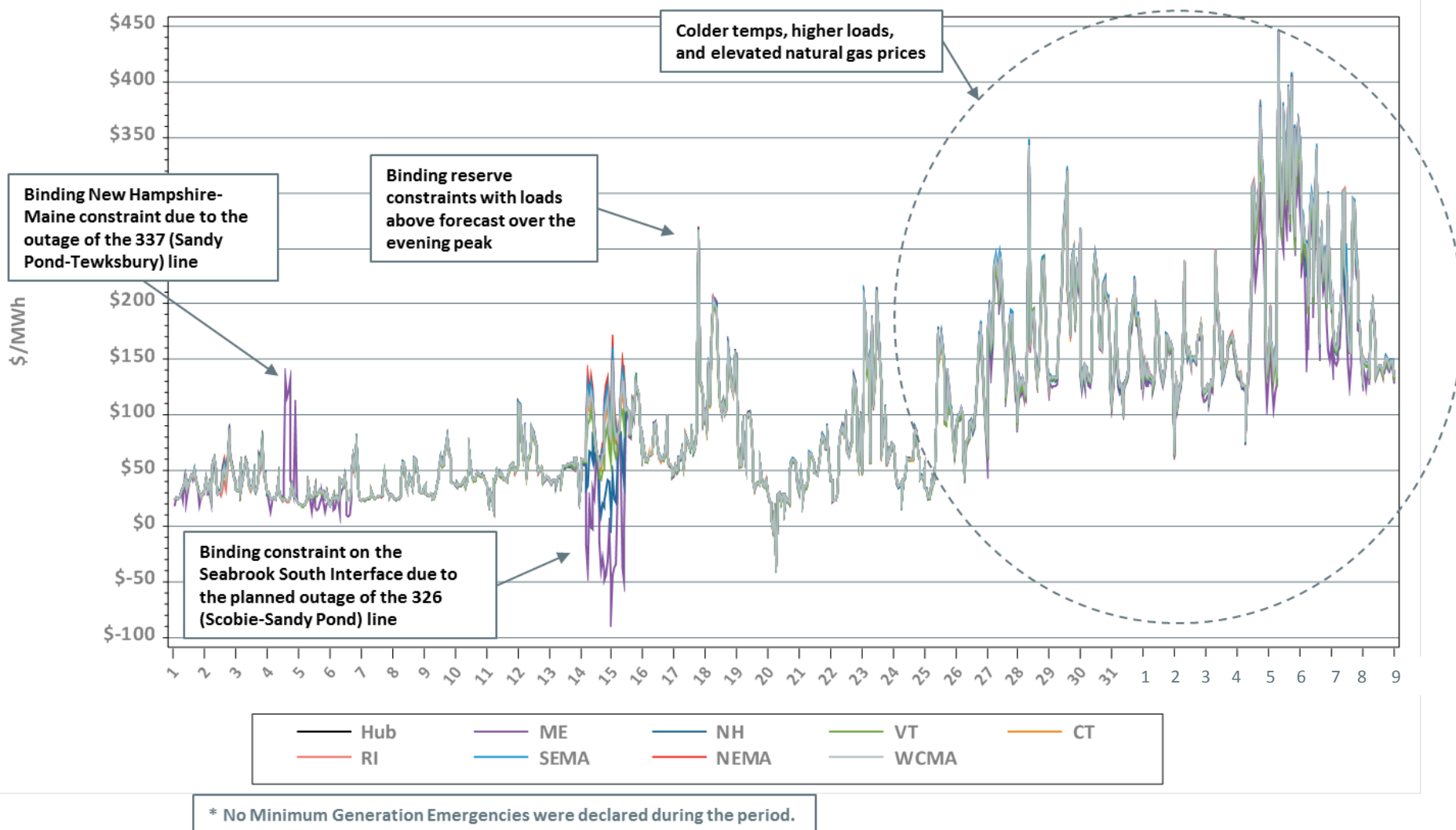
# Hourly DA LMPs, December 1-January 8

Hourly Day-Ahead LMPs

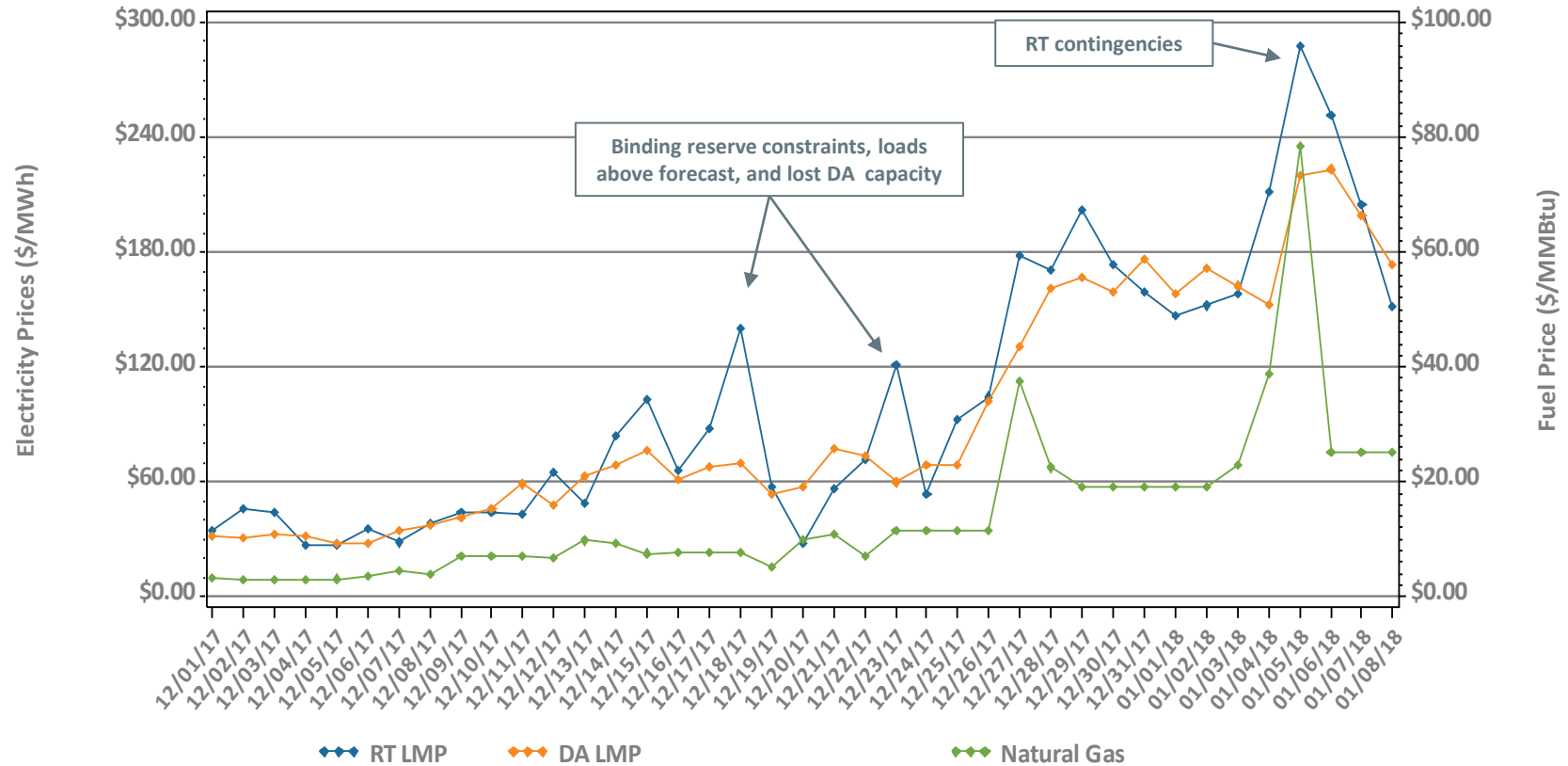


# Hourly RT LMPs, December 1-January 8

Hourly Real-Time LMPs



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



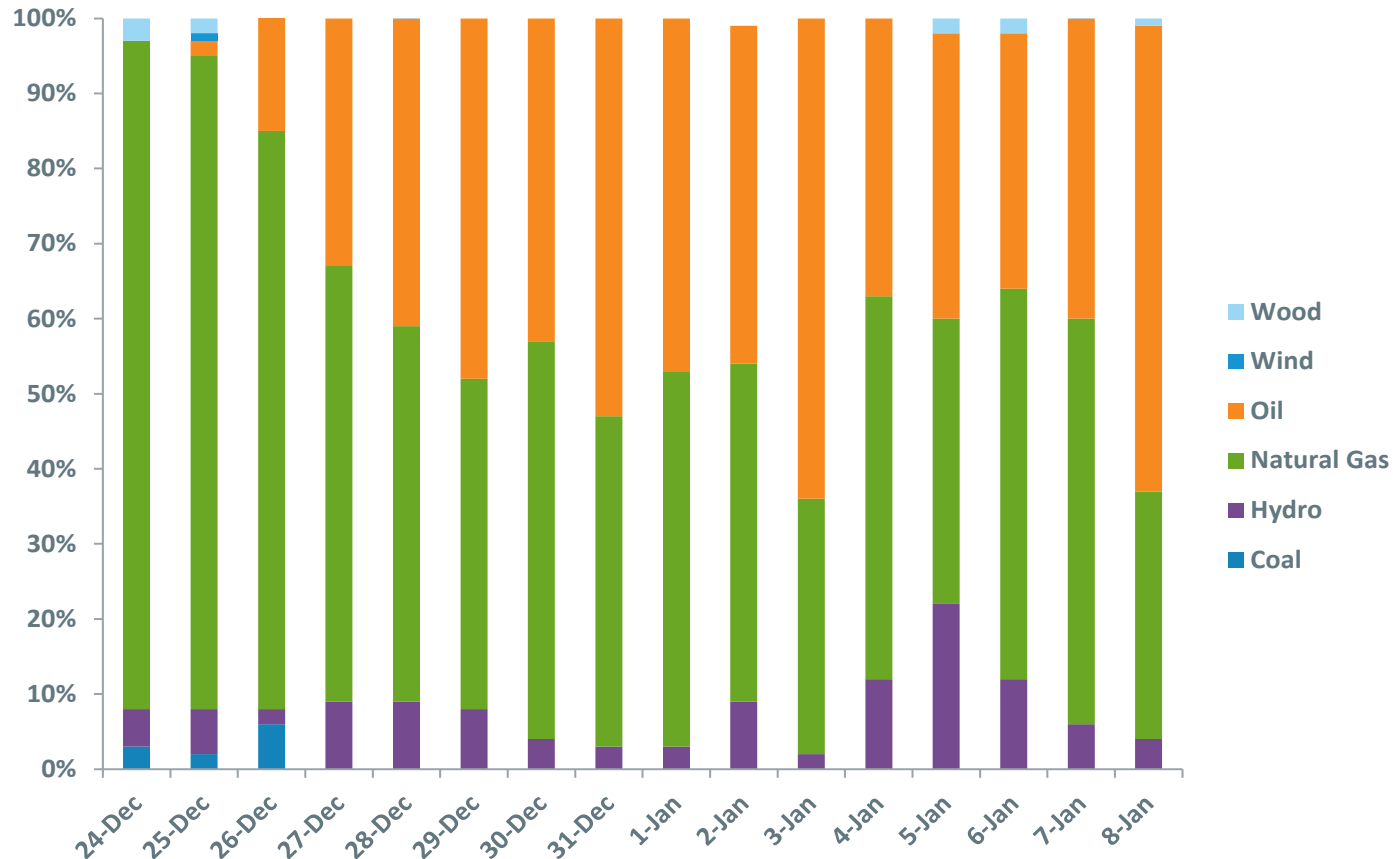
Underlying natural gas data furnished by:



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

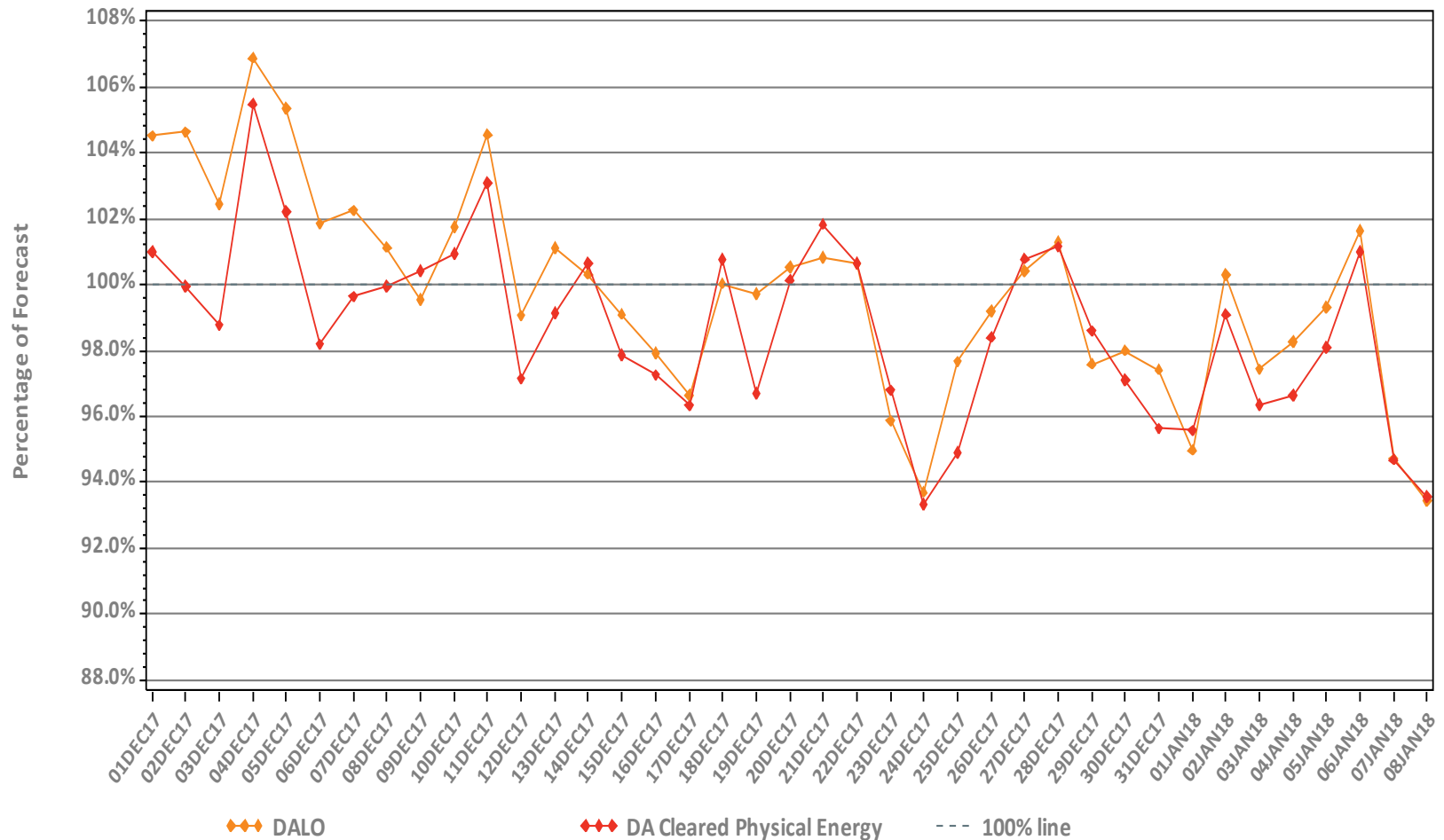


Note: Reflects price-setting by fuel-type during all intervals when the transmission system was unconstrained



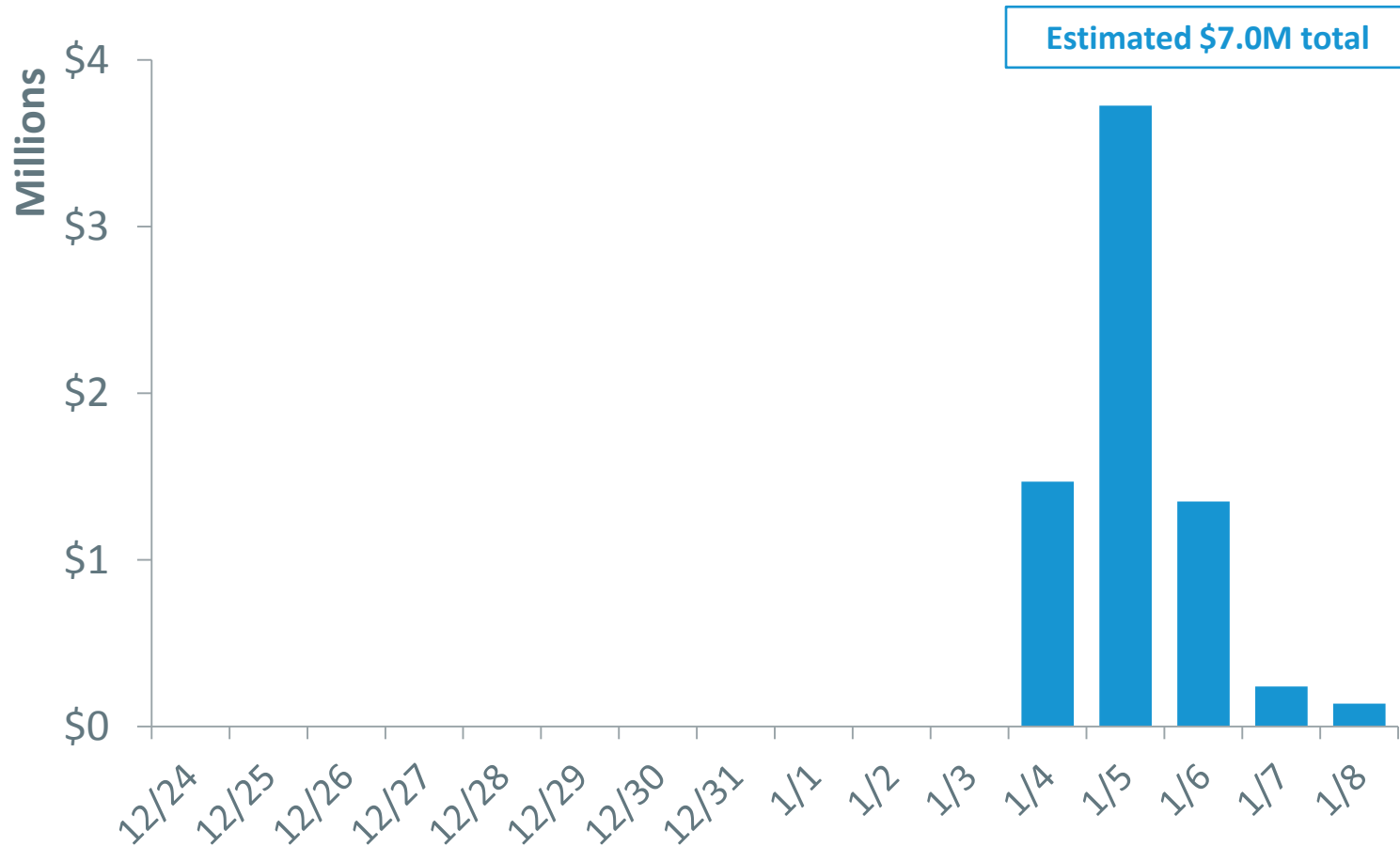
# DA Volumes as % of Forecast in Peak Hour

Daily: This Month



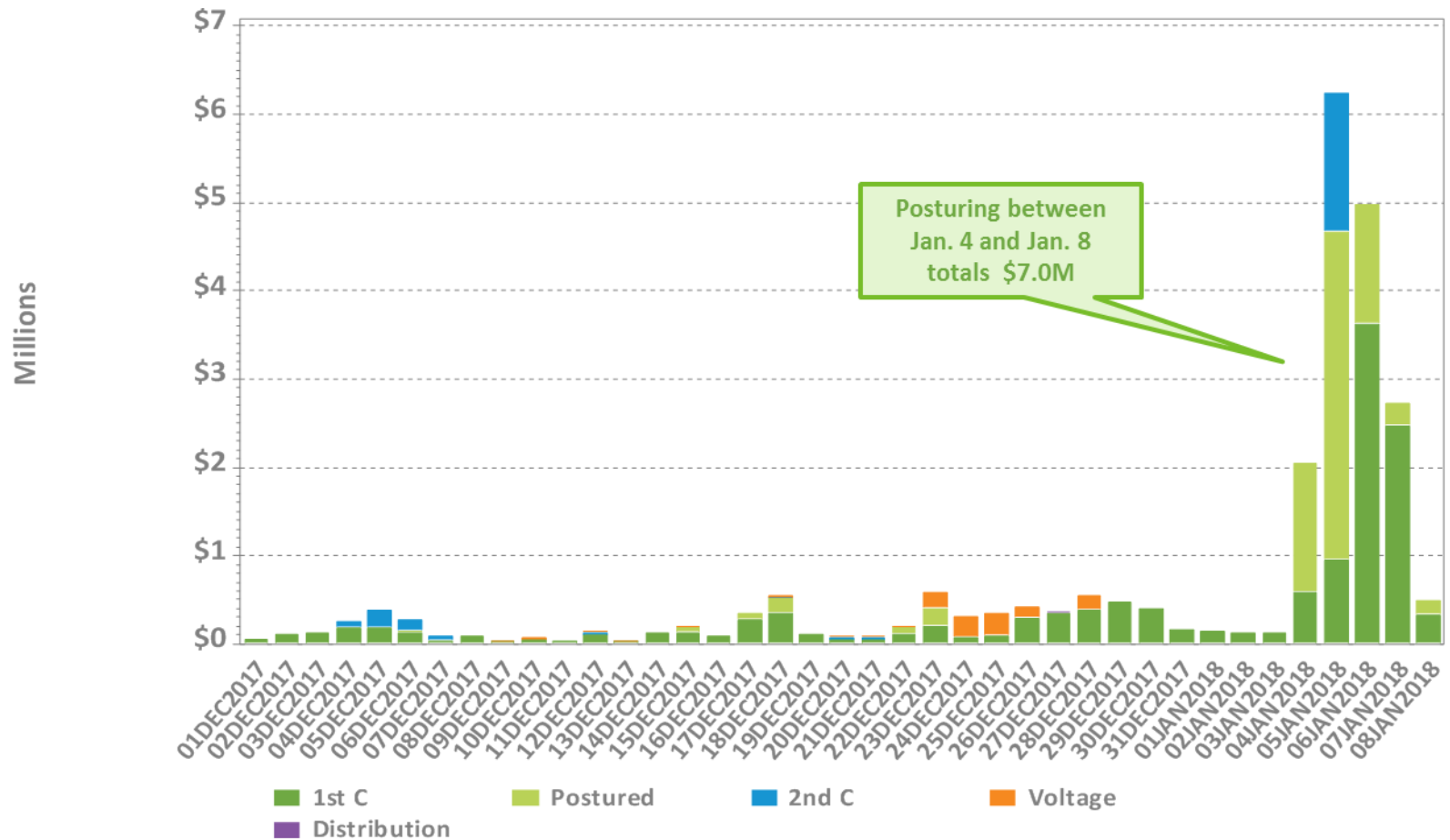
Note: DA Cleared Physical Energy includes DA generation and net imports

# Real-Time Posturing NCPC



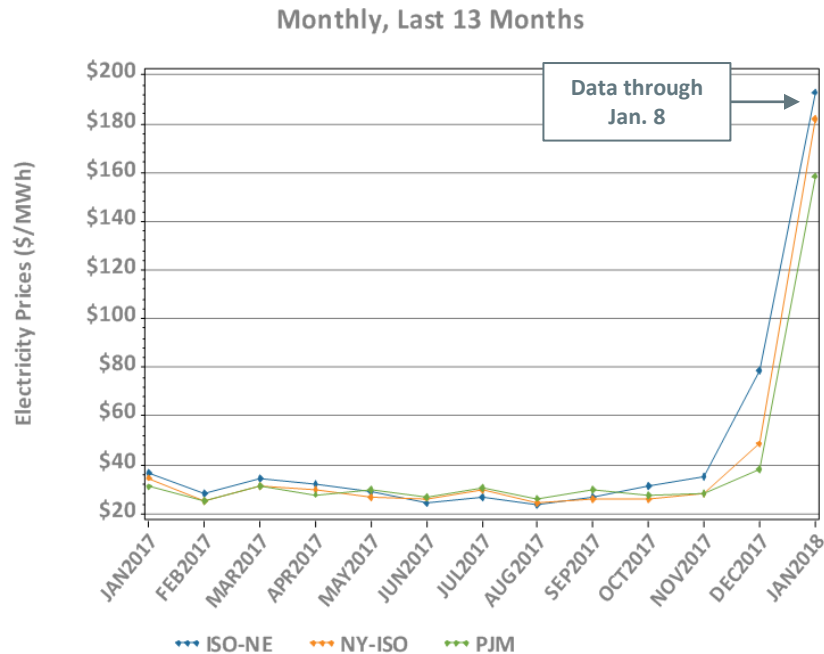
Does not show 'totals' of generation deviations charged to postured resources

# Daily NCPC Charges by Type

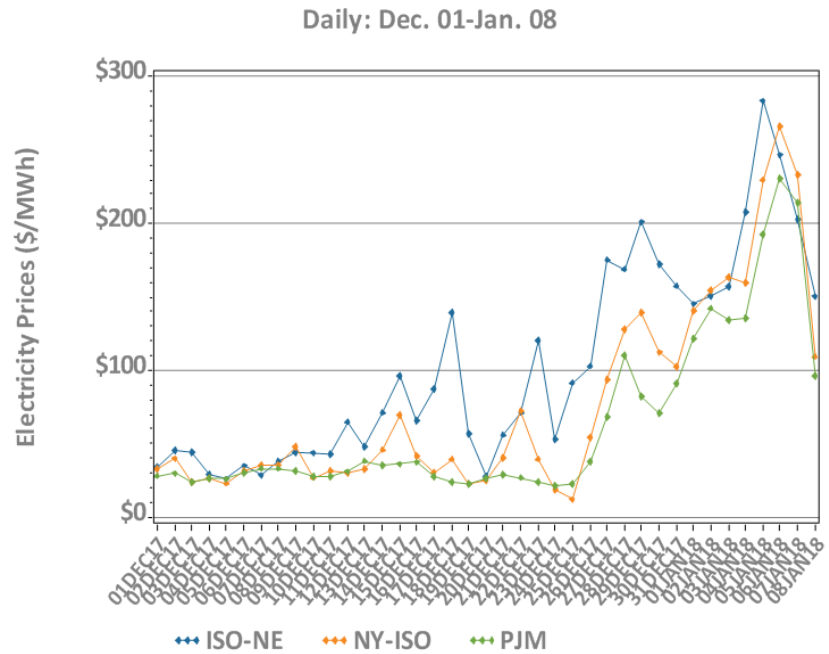


Note: Data for January 5-8 reflect preliminary settlements

# 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

