ISO New England

Post Winter 2017/18 Review

Planning Advisory Committee

Mark Babula

System Planning – Resource Adequacy
Table of Contents

• Post Winter 2017/18 Review
  – Weather, Energy and Peak Loads
  – Winter Reliability Program
  – Electric System Operations Review
  – Cold Weather Operations
  – Natural Gas System Operations Review
  – Appendix 1 – ISO-NE COO NPC Presentation on Cold Weather Operations
WINTER 2017/18 WEATHER, ENERGY AND PEAK LOADS
Winter 2017/18 Weather, Energy and Peak Loads*

• December 2017: Colder than previous December
  – Monthly Heating Degree Days (HDD) of 1,161 is 14.7% higher than December 2016
  – Energy demand of 11,082 GWh is 1.8% higher than December 2016
  – Peak load of 20,476 MW is 4.2% higher than December 2016
  – Peak occurred on December 28, 2017 at HE 18:00 at 8°F and -10°DWPT

• January 2018: Colder than previous January
  – Monthly HDD of 1,212 is 20.6% higher than January 2017
  – Energy demand of 11,493 GWh is 7.2% higher than January 2017
  – Peak load of 20,599 MW is 5.1% higher than January 2017
  – Peak occurred on January 5, 2018 at HE 18:00 at 8°F and -10°DWPT

(*) – All data obtained from the ISO-NE Net Energy and Peak Load Report located at:
Winter 2017/18 Weather, Energy and Peak Loads* - cont’d

• February 2018: Milder than previous February
  – Monthly HDD of 827 is 4.7% lower than February 2017
  – Energy demand of 9,345 GWh is 1.0% lower than February 2017
  – Peak load of 18,256 MW is 0.5% higher than February 2017
  – Peak occurred on February 7, 2018 at HE 18:00 at 29°F and 27°DWPT

• March 2018: Milder than previous March
  – Monthly HDD of 907 is 10.4% lower than March 2017
  – Energy demand of 9,925 GWh is 4.8% lower than March 2017
  – Peak load of 16,855 MW is 3.7% lower than March 2017
  – Peak occurred on March 7, 2018 at HE 18:00 at 33°F and 31°DWPT

(*) – All data obtained from the ISO-NE Net Energy and Peak Load Report located at:
WINTER RELIABILITY PROGRAM
Winter 2017/18 Reliability Program (As of the Start of the Program on December 1, 2017)

• Oil Program
  – Participation from 86 units for a total of 3.868 million barrels of oil
  – 2.867 million barrels of the total inventory on December 1 are eligible for compensation per the winter reliability program rules
  – Total oil program cost exposure is projected to be $29.62 Million (@$10.33/barrel)

• LNG Program
  – No Participation

• DR Program
  – Participation from 3 assets providing 7.5 MW of interruption capability
  – Total DR program cost exposure is projected to be $23.2K
Winter 2017/18 Reliability Program Usage

• Winter Program Oil Inventory Use\(^{(A)}\)
  - Dec 2017: 548,410 BBLs
  - Jan 2018: 524,447 BBLs
  - Feb 2018: 192,113 BBLs
  - Mar 2018: 48,356 BBLs
  TOTAL = 1,313,326 BBLs

• Winter Program LNG Use:
  – None

• Winter Program DR Use (Events):
  – None

• Final Program Ending Oil Eligible Inventory\(^{(B)}\)
  – 2,566,435 BBLs

NOTE (A): First of month snapshot of oil inventory
NOTE (B): End of WRP Inventory on March 15, 2018 = Amount used for Billing Calculations
Winter Reliability Program Costs & Billing

• Anticipated Program Costs:
  – Oil: $24.4M* ($22.2M collected; $2.2M remains to be collected)
  – DR: $33K ($28K collected; $5K remains to be collected)

• Billing/Payment Schedule:
  – Initial billings were based on 75% of initial inventory
  – Trued-up charges for unused fuel was issued on April 17, 2018
  – Payment to generators for unused fuel inventory will be in May 14, 2018 bill

* Fuel inventory cost with preliminary availability adjustment
First of the Month Oil Inventory – All Units

New England Oil Inventory
(At the First of Each Month)

- Winter 2016-2017
- Winter 2017-2018

Barrels of Oil

Month: December, January, February, March
ELECTRIC SYSTEM OPERATIONS REVIEW
# Electric System Operations Review

<table>
<thead>
<tr>
<th>Event Type</th>
<th>December 2017</th>
<th>January 2018</th>
<th>February 2018</th>
<th>March 2018</th>
</tr>
</thead>
<tbody>
<tr>
<td>OP4</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>MLCC2 (Reason)</td>
<td>None</td>
<td>January 3 – 9 (Severe Weather)</td>
<td>None</td>
<td>March 7-9 March 12-15 March 16 in NSTAR Only March 20-22 (Severe Weather)</td>
</tr>
<tr>
<td>Peak Load Date (H.E.)</td>
<td>20,531 MW Dec 28 (18:00)</td>
<td>20,631 MW Jan 5 (18:00)</td>
<td>18,164 MW Feb 7 (18:00)</td>
<td>16,735 MW Mar 7 (19:00)</td>
</tr>
<tr>
<td>Minimum Gen Warning/Event</td>
<td>None</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>

Peak load & dates come from ISO-NE’s monthly COO-NPC reports
Electric System Operations – December 2017

<table>
<thead>
<tr>
<th>Weather Patterns</th>
<th>Boston</th>
<th>Hartford</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temperature: Below Normal (-6.1°F)</td>
<td>Temperature: Below Normal (-5.9°F)</td>
</tr>
<tr>
<td></td>
<td>Max: 59°F, Min: 2°F</td>
<td>Max: 59°F, Min: 3°F</td>
</tr>
<tr>
<td></td>
<td>Precipitation: 2.47” – Below Normal</td>
<td>Precipitation: 2.42” - Below Normal</td>
</tr>
<tr>
<td></td>
<td>Normal: 3.73”</td>
<td>Normal: 3.60”</td>
</tr>
<tr>
<td></td>
<td>Snow: 7.16”</td>
<td>Snow: 8.94”</td>
</tr>
</tbody>
</table>

Peak Load: 20,531 MW, Dec 28, 2017, 18:00 (ending)

MLCC2: None

OP-4: None

NPCC Simultaneous Activation of Reserve Events:

<table>
<thead>
<tr>
<th>Date</th>
<th>Area</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>December 7</td>
<td>NYISO</td>
<td>1,240</td>
</tr>
</tbody>
</table>

Minimum Generation Warnings & Events:

None
## Electric System Operations – January 2018

<table>
<thead>
<tr>
<th>Weather Patterns</th>
<th>Boston</th>
<th>Hartford</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature: Below Normal (-0.4°F) Max: 61°F, Min: -2°F Precipitation: 4.77” – Above Normal Normal: 3.04” Snow: 15.4”</td>
<td></td>
<td>Temperature: Below Normal (-1.3°F) Max: 60°F, Min: -9°F Precipitation: 3.83” - Above Normal Normal: 2.91” Snow: 13.2”</td>
</tr>
</tbody>
</table>

### Peak Load:
- **20,631 MW** on **Jan 5, 2018**
- **18:00 (ending)**

### MLCC2:
- Reason: Extreme weather followed by extreme cold temperatures
- Declared: Jan 3, 2018 16:00
- Cancelled: Jan 9, 2018 12:00

### OP-4:
- None

### NPCC Simultaneous Activation of Reserve Events:

<table>
<thead>
<tr>
<th>Date</th>
<th>Area</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>January 1</td>
<td>PJM</td>
<td>700</td>
</tr>
<tr>
<td>January 3</td>
<td>PJM</td>
<td>1,000</td>
</tr>
<tr>
<td>January 4</td>
<td>ISO NE</td>
<td>680</td>
</tr>
<tr>
<td>January 7</td>
<td>NYISO</td>
<td>600</td>
</tr>
<tr>
<td>January 7</td>
<td>IESO</td>
<td>600</td>
</tr>
<tr>
<td>January 25</td>
<td>ISO NE</td>
<td>700</td>
</tr>
</tbody>
</table>

### Minimum Generation Warnings & Events:
- None
## Electric System Operations – February 2018

<table>
<thead>
<tr>
<th>Weather Patterns</th>
<th>Boston</th>
<th>Hartford</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temperature: Above Normal (5.7°F) Max: 72°F, Min: 10°F Precipitation: 3.76” – Above Normal Normal: 2.86” Snow: 9.8”</td>
<td>Temperature: Above Normal (5.0°F) Max: 77°F, Min: 9°F Precipitation: 5.13” – Above Normal Normal: 2.56” Snow: 8.3”</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Peak Load:</th>
<th>18,164 MW</th>
<th>Feb 7, 2018</th>
<th>18:00 (ending)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>MLCC2:</th>
<th>None</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>OP-4</th>
<th>None</th>
</tr>
</thead>
</table>

### NPCC Simultaneous Activation of Reserve Events:

<table>
<thead>
<tr>
<th>Date</th>
<th>Area</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>February 3</td>
<td>NYISO</td>
<td>1,302</td>
</tr>
<tr>
<td>February 16</td>
<td>NYISO</td>
<td>1,000</td>
</tr>
</tbody>
</table>

### Minimum Generation Warnings & Events:

None
## Electric System Operations – March 2018

<table>
<thead>
<tr>
<th>Weather Patterns</th>
<th>Boston</th>
<th>Hartford</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temperature:</strong> Below Normal (-1.1°F)</td>
<td>Max: 64°F, Min: 16°F</td>
<td>Max: 60°F, Min: 17°F</td>
</tr>
<tr>
<td><strong>Precipitation:</strong> 5.07” – Above Normal</td>
<td>Normal: 4.32”</td>
<td>Precipitation: 2.65” - Below Normal</td>
</tr>
<tr>
<td><strong>Snow:</strong> 23.3” – Above Normal</td>
<td>Snow: 16.6” – Above Normal</td>
<td></td>
</tr>
</tbody>
</table>

### Peak Load:
- **16,735 MW**
- **March 7, 2018**
- **19:00 (ending)**

**MLCC2:**
- **Reason:** Severe Weather
- **Declared:** March 7, 2018 HE 09:00
- **Cancelled:** March 9, 2018 HE 21:00

**MLCC2:**
- **Reason:** Severe Weather
- **Declared:** March 12, 2018 HE 14:00
- **Cancelled:** March 15, 2018 HE 12:00

**MLCC2:**
- **Reason:** Severe Weather
- **Declared:** Continued in NSTAR only
- **Cancelled:** March 16, 2018 HE 16:00

**MLCC2:**
- **Reason:** Severe Weather
- **Declared:** March 20, 2018 HE 16:00
- **Cancelled:** March 22, 2018 HE 12:00

**OP-4:** None
### Minimum Generation Warnings & Events:

| None |

### NPCC Simultaneous Activation of Reserve Events

<table>
<thead>
<tr>
<th>Date</th>
<th>Area</th>
<th>MW Lost</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 8</td>
<td>ISO-NE</td>
<td>1,600</td>
</tr>
<tr>
<td>March 14</td>
<td>ISO-NE</td>
<td>2,006</td>
</tr>
<tr>
<td>March 19</td>
<td>NYISO</td>
<td>400</td>
</tr>
<tr>
<td>March 19</td>
<td>ISO-NE</td>
<td>660</td>
</tr>
</tbody>
</table>
COLD WEATHER OPERATIONS
DECEMBER 25, 2017 – JANUARY 8, 2018
Cold Weather Operations

• New England was gripped by cold weather between December 25, 2017 and January 8, 2018

• Natural gas and fuel oil price inversion led to fuel oil being in economic merit and subsequently base loaded
  — As natural gas prices rose, the entire season’s oil supply rapidly depleted. Coal use also increased over normal use

• With extended days of burning oil, several resources had concerns about hitting federal and/or state emissions limitations or were directly impacted by emissions limitations
  — This primarily includes resources in MA, CT and RI

• Sea/river ice affected ship and barge deliveries to fuel oil terminals located in NH, ME and on the Hudson River
Frigid Cold Drove Up Regional Demand for Natural Gas

This led to spikes in natural gas prices, which then led to spikes in wholesale electricity prices; with natural gas at a premium, oil generation became economic.

Cold Weather Period Prices for Natural Gas and Wholesale Electricity

- Natural Gas $/MMBtu
- $287.85
- $78.35
- $5.75

Underlying natural gas data furnished by: ICE Global markets in clear view
Winter Natural Gas vs. Oil Consumption (Thousand Mcf, Barrels) and Net Generation (Thousand MWh)

Source: EIA
Estimated CO₂ System Emissions During Cold Snap

Daily Average 220,680, total reached 3.5 million Short Tons
Cold Weather Operations – cont’d

• Trucking transport of fuel oil was the primary refueling constraint

• Massachusetts Governor Baker signs hours-of-service waivers to provide fuel deliveries for residential and commercial customers, and power plants

• To increase situational awareness, the ISO initiated semi-weekly then daily fuel surveys of oil-fired generation

• 37 natural gas issues were reported for the period, primarily Operational Flow Orders (OFOs) on Algonquin, Iroquois, and Tennessee Gas Pipelines; 2 in-region force majeure declared
  – ISO-NE requested two conference calls with the Northeast Gas Association’s - Gas Supply Task Force
  – ISO-NE was in daily communications with interstate pipeline operators
Cold Weather Operations – cont’d

• Emergency conference calls were held with both NPCC Reliability Coordinators and the six Local Control Centers to review current and emerging issues

• M/LCC 2 was declared on January 3 for all of New England due to; extreme weather, extreme cold, and fuel supply concerns. Subsequently cancelled on January 9

• The system operated reliably through the extended cold weather event. It relied heavily on oil to meet demand
  – The aggregate performance of the available generation fleet over the duration of the cold spell was good

• Reference Appendix 1 of this presentation for ISO-NE’s COO-NPC presentation
Electric System Operations Review – Conclusions

• Aside from the cold weather event that occurred over the winter holiday, system operations this winter was also impacted by additional severe coastal weather and snowstorms; challenges remain for future winters with regard to fuel security and retirements

• World LNG prices and futures’ contracts impact on how much LNG shows up in New England
  – Increased LNG injections maintain both electric and gas grid reliability
  – No LNG volumes participated in the Winter Reliability Program

• The Winter Reliability Program was instrumental in augmenting liquid fuel security for the region
  – The Pay-For-Performance market design becomes effective in June 2018
NATURAL GAS SYSTEM OPERATIONS REVIEW
Natural Gas System Operations Review – Summary of Issues and Incidents

• December 2017:
  - 19 gas system issues and 2 incidents at generating stations

• January 2018:
  - 15 gas system issues and 2 incidents at generating stations

• February 2018:
  - 2 gas system issues and 4 incidents at generating stations

• March 2018:
  - 1 gas system issue and 1 incident at generating stations

Total Winter Period:
  - 37 gas system issues and 9 incident at generating stations
Natural Gas System Operations Review –
Declarations of Force Majeure & OFOs

• Algonquin Gas Transmission (AGT) Force Majeure: None
• AGT OFOs:
  - Dec 7 to Dec 31
  - Jan 1 to Jan 10, Jan 13 to Jan 19, Jan 24 to Jan 26, Jan 29 to Feb 5
  - Feb 8 to Feb 9
  - Mar 2 to Mar 27

• Iroquois Gas Transmission System (IGTS) Force Majeure:
  - Interruption at Milford, CT compressor station from Jan 14 to Jan 15
• IGTS OFOs:
  - Dec 13 to Dec 18, Dec 27 to Dec 31
  - Jan 4 to Jan 9 and Jan 9 to Jan 10
  - Feb 1 to Feb 2
Natural Gas System Operations Review –
Declarations of Force Majeure & OFOs – cont’d

- Maritimes & Northeast (M&N) Pipeline Force Majeure: None
- M&N OFOs: None

- Portland Natural Gas Transmission System (PNGTS)
  Force Majeure: None
  - However, a cyber security issue with PNGTS’ EBB was reported on March 31
- PNGTS OFOs: None
Tennessee Gas Pipeline (TGP) Force Majeure:
- Gas restriction on Dec 15 gas-day for a valve control failure near Nassau, NY
- Station 241–Unit 1B near Syracuse, NY on Jan 8
- Urgent repair at Agawam compressor station from Feb 7 to Feb 20

TGP OFOs (All types*):
- Monthly OFO = 2 (includes carry over OFO)
- Action OFO = 1
- Critical Day 1 OFO = 31
- Critical Day 2 OFO = 0
- Balancing OFO = 6
- Hourly OFO = 0
- Meter Specific OFO = 1

(*) – Does not indicate the number of days that any OFO may have been in place.
Natural Gas Schedules – December 1, 2017 Through March 1, 2018

Natural Gas Schedules to Generators vs. Non-Power Use - Winter 2017 - 2018

New England pipeline schedule data provided by Genscape
Canaport and Distrigas Send-Out to New England Gas Pipelines

LNG Sourced Deliveries to New England Pipelines

- **Month**
  - Nov
  - Dec
  - Jan
  - Feb

- **MMBtu**
  - 0
  - 2,000,000
  - 4,000,000
  - 6,000,000
  - 8,000,000
  - 10,000,000
  - 12,000,000

- **2016/17**
- **2017/18**
Natural Gas System Operations Review - Conclusions

• Natural gas pipeline operators provided vital information to ISO-NE Forecasters with regards to the operational integrity and flexibility of their systems to serve non-core power plant demands

• Regional LNG import terminal owners/operators provided vital information to ISO-NE Forecasters with regards to daily send-out capabilities and LNG tanker resupply logistics

• The Northeast Gas Association (NGA) was responsive to ISO-NE’s request to convene two ad-hoc meetings of its Gas Supply Task Force (GSTF) to inform ISO-NE Staff of overall system conditions in the New Jersey, New York, and New England regions.
Questions
APPENDIX 1 - COLD WEATHER OPERATIONS
DECEMBER 24, 2017 – JANUARY 8, 2018
Cold Weather Operations

December 24, 2017 – January 8, 2018

Vamsi Chadalavada

EXECUTIVE VICE PRESIDENT AND CHIEF OPERATING OFFICER
Appendix 1 - Table of Contents

• Cold Weather Conditions Page 38
• Fuel Mix Page 45
• Cold Weather Oil Usage Page 50
• Cold Weather Fuel Logistics Page 59
• System Operations Page 69
• PV and Wind Output Page 81
• Market Data Page 86
• Summary & Next Steps Page 97
COLD WEATHER OPERATIONS
DECEMBER 24, 2017 – JANUARY 8, 2018
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

8 New England Cities Mean Temperature Departure from Normal °F
Dec. 24, 2017 - Jan 08, 2018

-30 -25 -20 -15 -10 -5 0 5 10

°F


BOS  BDL  ORH  BDR  PVD  CON  PWM  BTV  AVG
Coldest December Mean Temps since at least 2000

December Mean Temperatures Boston & Hartford 2000 - 2017

- Boston
- Hartford
- 2000
- 2017
- 2017
Coldest January 1-8 since at least 2000

January 1-8 Mean Temperatures Boston & Hartford 2000 - 2018
Arctic Outbreak 2017-18 Boston Temperatures

- 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)

Day-to-Day Generation by Fuel Type

- NG/LNG
- Oil
- Nuclear
- Coal
- Renewables (Including Wind and Hydro)

% of Total System Generation
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

- Winter Program Generators
- Non-Winter Program Generators

Survey Period:
- 1/1 to 1/4
- 1/4 to 1/5
- 1/5 to 1/6
- 1/6 to 1/7
- 1/7 to 1/8
- 1/8 to 1/9

Barrels of Oil

- 350,000
- 300,000
- 250,000
- 200,000
- 150,000
- 100,000
- 50,000
- 0
Generator Oil Burn – Yearly Comparison

![Bar Chart: Generator Oil Burn]

- Year 2016
- 1/1/17 to 12/24/17
- 12/25/17 to 1/9/18

Bars represent barrels of oil consumed during the survey period.
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

Days of Oil On Site

- Max
- 12/1/17
- 1/1/18
- 1/4/18
- 1/5/18
- 1/6/18
- 1/7/18
- 1/8/18
- 1/9/18
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
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 Prices - Massachusetts vs. Marcellus

MA_natgas4  Marcellus
Natural Gas Schedules to Generators vs. Non-Power Use - Winter 2017 - 2018
Scheduled Data from Pipeline Electronic Bulletin Boards - Not Actual Flow

- Pipeline Generators
- Non Power
- LNG
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

Actual Load vs Forecasted Load

- Day Ahead Forecasted Load
- Actual Hourly Load

MW

12/24 12/25 12/26 12/27 12/28 12/29 12/30 12/31 01/01 01/02 01/03 01/04 01/05 01/06 01/07 01/08 01/09
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. 800 MW of capability) had planned outages/reductions rescheduled
  – 2 transmission line outages were rescheduled for a later date
## System Operations: Transmission

### Significant Transmission Events:

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

New England Generation Outages and Reductions

- Outages
- Reductions
- Total

MW

12/24 12/25 12/26 12/27 12/28 12/29 12/30 12/31 1/1 1/2 1/3 1/4 1/5 1/6 1/7 1/8 1/9
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

Estimated Behind the Meter PV Output

Derived from statistical sampling of actual meter readings

- Estimated Output
- Winter Irradiance Potential
- Nameplate Capacity
PV Generation – In Front of the Meter
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 DA Mkt Value

$68.6M Daily Average

$18.7M Daily Average

DA Market is 97% of Total Energy Market Value
Daily System Load Increased 21% after Christmas

Telemetered system load values

Daily Total MWh

Thousands

342,000 MWh Avg

413,000 MWh Avg

Daily NEL up 21%
Hourly DA LMPs, December 1-January 8

Hourly Day-Ahead LMPs

Colder temps, higher loads, and elevated natural gas prices

$/MWh

0 50 100 150 200 250 300 350 400 450

%
Hourly RT LMPs, December 1-January 8

Colder temps, higher loads, and elevated natural gas prices

Binding New Hampshire-Maine constraint due to the outage of the 337 (Sandy Pond-Tewksbury) line

Binding reserve constraints with loads above forecast over the evening peak

Binding constraint on the Seabrook South Interface due to the planned outage of the 326 (Scobie-Sandy Pond) line

* 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

**Electricity Prices ($/MWh)**
- $0.00
- $60.00
- $120.00
- $180.00
- $240.00
- $300.00

**Fuel Price ($/MMBtu)**
- $0.00
- $20.00
- $40.00
- $60.00
- $80.00
- $100.00

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

**Gas price is average of Massachusetts delivery points**

*Binding reserve constraints, loads above forecast, and lost DA capacity***

RT LMP

DA LMP

Natural Gas

Underlying natural gas data furnished by:
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

Estimated $7.0M total

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

**Monthly, Last 13 Months**

- Data through Jan. 8

**Daily: Dec. 01-Jan. 08**

- *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