Winter Operations Summary: January – February 2013

ISO New England
February 27, 2013

Introduction

ISO New England has immediate and growing concerns about the availability and flexibility of generating resources—particularly natural gas and oil-fired resources—to reliably serve the daily, round-the-clock demands of electricity consumers in New England.

The just-in-time nature of the natural-gas fuel delivery system, combined with the competitive pressures imposed by the wholesale electricity markets and the rational business strategy of gas and oil-fired generating facilities to minimize operating costs, is causing persistent reliability concerns, which are most acute during extended cold-weather periods when natural gas demand by local distribution companies (LDCs) is high. These concerns have also materialized when the interstate natural-gas pipelines perform maintenance or are otherwise constrained, and when liquefied natural gas (LNG) inventories or injections into the interstate pipelines are low. These concerns have been documented through the ISO's Strategic Planning Initiative and the ISO is already working with stakeholders to develop short- and long-term solutions to this and other strategic risks. However, operating conditions this winter have exposed the urgency of taking additional actions to address these growing concerns. The key point from this winter is that the region needs to develop immediate solutions to avert serious threats to system reliability next winter and during the transition period until the market design changes that are being considered by the ISO and its stakeholders become effective.

Overview of Summary

The purpose of this summary is to provide New England stakeholders with information about real-world operating challenges that ISO system operators experienced this winter. The weather has not been unusually cold this winter and the only unusual weather event was a blizzard in February. The ISO's concern is not primarily the weather, but the lack of secure fuel arrangements for resources to operate when the gas-supply system is constrained, which often coincides with cold weather. This information is intended to inform ongoing discussions of potential solutions to the region's significant dependence on natural gas. The ISO plans to update this document as operating conditions warrant and in response to feedback from ISO New England stakeholders.

This summary is organized in the following sections:

- Section 1 provides background on winter operating events in January and February 2013
- Section 2 provides information on temperatures in the region
- Section 3 provides information on operating conditions and challenges
- Section 4 discusses operating reserve margins during the week of January 21
- Section 5 describes fuel-supply challenges during the February storm
- Section 6 describes the challenges of the winter load profile
- Section 7 describes energy prices in New England
- Section 8 identifies key observations
- Section 9 discusses conclusions, and
- Section 10 identifies next steps.

Section 1. Background on winter operating events

In late January 2013, New England experienced the coldest five-day stretch since 2009 and two weeks later, in February, a weekend blizzard left record snowfall across the region, which prompted governors to shut highways across New England so crews could clear the roads. In some parts of the region, the blizzard snowed residents in for days.

The cold stretch occurred Monday, January 21, through Friday, January 25, but no major power outages were reported during this period and system conditions did not require ISO New England to implement any emergency procedures.

The blizzard occurred Friday, February 8, and continued into Sunday, February 10, knocking out power to more than 645,000 distribution customers, primarily in southern New England. Again, system conditions did not require the ISO to implement any emergency procedures.

During both events, however, the ISO had to commit additional generating resources to ensure adequate resources were available under volatile weather and operating conditions. These commitments were driven by the inadequacy of generator fuel arrangements and the uncertainty this created for ISO system operators. The ISO also needed to commit resources in key locations to manage the volatility of transmission, generation and customer outages in areas hit hard by the February blizzard. These resources were committed out-of-economic-merit order and contributed to significant "uplift" costs to consumers in the region.

The ISO issued alerts in advance of each of these events, which instructed power-system personnel to keep all power-system equipment in service and available to the ISO throughout the duration of both events. The alerts remained in effect throughout the events, which is routine. In addition, the ISO did implement an operating procedure to deal with a tight capacity situation (i.e., a capacity deficiency) one evening following the January cold stretch.

The lack of more severe ISO actions, however, is not a true indication of the volatility of operating conditions that have persisted throughout the winter, severely testing the reliability of the New England power system.

These two events presented extreme challenges for ISO New England system operators and the operators of power system resources across the six-state region. Some of the challenges were obvious – generation-plant personnel keeping the plants operating during cold temperatures, high winds and snowy weather, distribution companies restoring electrical service to customers whose power was knocked out during the storm. Other challenges, particularly for ISO New England system operators, were less obvious.

High wholesale electricity prices, to which federal officials have recently drawn attention, are an indicator of the challenge, but do not explain the severity of the challenge, which is this: the region's growing dependence on natural gas for power generation is a rapidly-escalating strategic risk for the region. This dependence on natural gas and the declining utilization of oil for power generation, have contributed to major reductions in oil inventories at power plants in the region. This risk has already materialized in the ISO New England control room as operators must manage the system in the face of growing uncertainty of the fuel supply for natural gas and oil-fired generating resources—a condition that is unsustainable.

Section 2. Temperature and demand for electricity

Temperatures in New England were below freezing in all of the time periods evaluated in this summary. However, temperatures were not as cold this winter as in some earlier periods. See Figure 1. Temperatures during New England Cold-Weather Periods.

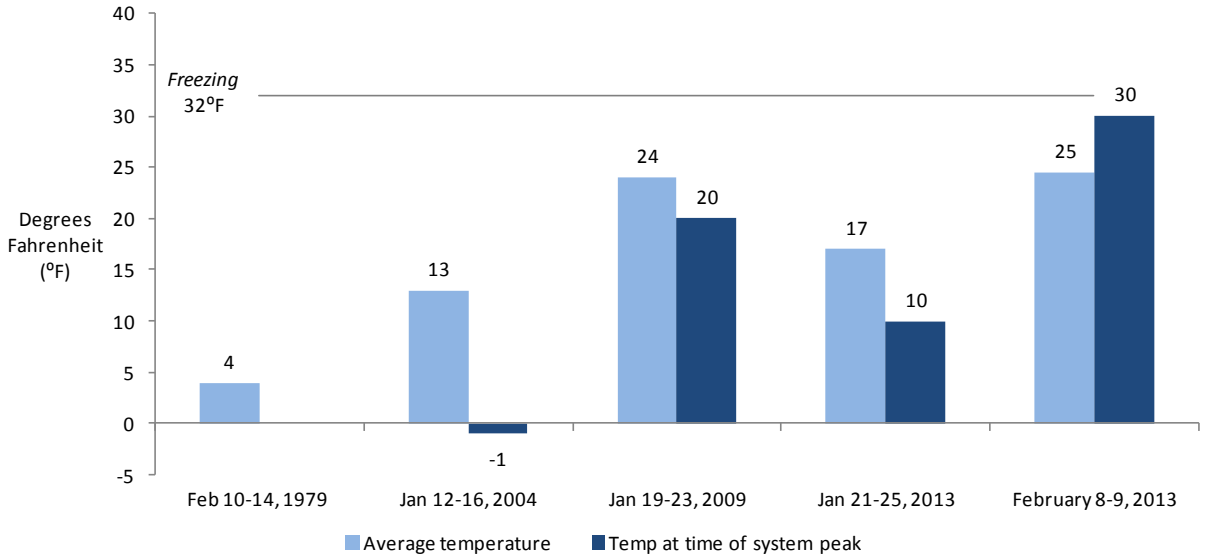

Figure 1. Temperatures during New England Cold-Weather Periods

In this chart, the *average temperature* is the average of Hartford and Boston temperatures. The *temperature at the time of the system peak* is a weighted value of eight weather stations in New England.

January 2013 vs. January 2004 cold snap

The week of January 21-25, 2013 was the coldest five-day stretch in New England since January 19-23, 2009. However, the temperatures in this 2013 time period were not nearly as cold as the January 2004 cold snap when the temperature dropped to minus one degree Fahrenheit (-1 °F) at the time of the January 15 electric-system peak.[1] The peak demand for electricity during the 2004 cold snap is the all-time wintertime record in New England, at 22,818 megawatts (MW).

The temperature at the time of the system peak during the 2004 cold snap was about 11 degrees colder than the temperature during the January 2013 time period. The peak demand for electricity in this January 2013 time period (20,800 MW) was about 2,000 MW lower than the 2004 cold snap.
In New England, the coldest five-day stretch since 1970 occurred February 10-14, 1979, when the five-day average temperature dropped to 4 degrees Fahrenheit.

February 8-9, 2013

Winter Storm Nemo dropped record snow across New England over a two-day period from Friday, February 8, to Saturday, February 9. Except for Vermont, where the maximum snowfall was 17 inches, the maximum snowfall across most of the region ranged from 30 to 40 inches. Wind speeds exceeded 80

[1] The cold weather can be compared by other measures. January 2013 had fewer heating degree days (1113 HDD), than normal (1194 HDD), and the January 2004 (1454 HDD), which was much colder than normal. A heating degree day is an indication of a building's demand for energy (fuel consumption) based on each degree the daily mean temperature is below 65F.

miles per hour in some parts of New England. Temperatures during the storm were cold, but not as cold as the earlier winter periods discussed above. The peak demand for electricity in this February 2013 time period (18,700 MW) was about 4,100 MW lower than the 2004 cold snap.

Temperatures in Hartford and Boston hovered at or below freezing on February 8 and dropped to the 15-to-25 degree range on February 9. The day after the storm (Sunday, February 10), temperatures in Boston started in the teens and climbed above freezing by midday. Temperatures were colder in Hartford on Sunday and dropped below zero before climbing to freezing by midday.

The close proximity of these events, shown in Figure 2 below, raises concerns for the region's ability to maintain electric-system reliability under more-sustained cold-weather events.

Inflexibility of fuel supply for power generation creates challenges across the winter season

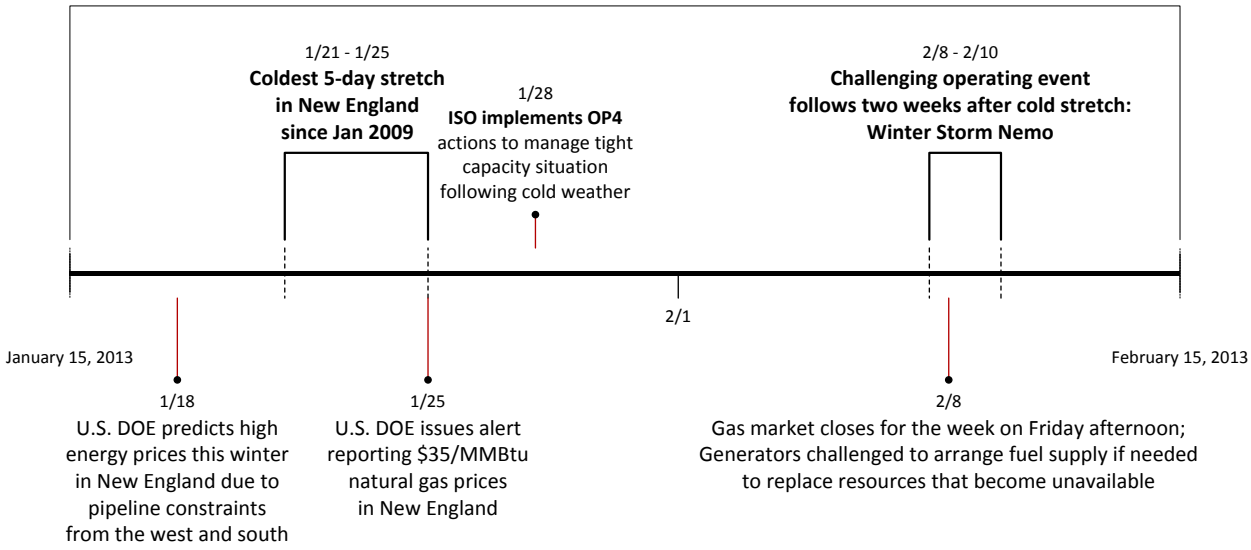

Figure 2. January - February 2013 Timeline

Section 3. Operating conditions and challenges

ISO system operators encountered a range of operating conditions and challenges for the January and February events highlighted below.

January 21-25, 2013

The following are highlights of operating challenges that occurred during the week of January 21.

Operating challenges:

- Cold weather also affected neighboring power systems; Hydro-Quebec set an all-time peak and limited exports to other regions
- New England received significant natural gas flows from the north, but pipelines were restricted from the west and south
- ISO's pre-winter fuel surveys showed that oil-fired generators do not maintain full oil tanks
- Economics drove some generators to switch from natural gas to oil, which reduced already-low oil inventories
- Oil inventories can be depleted rapidly during sustained cold weather when oil-fired generating resources operate either as economic resources or are committed by the ISO for reliability, which limits their ability to run at other times when gas supplies are constrained

- ISO committed additional generation to manage the inflexibility of fuel delivery to gas-fired generators, which is particularly acute during evening, overnight, and weekend hours and in situations where gas-fired generators have not contracted for fuel delivery
- Some resources needed earlier in the day than planned became unavailable for extended operation because they had incorrectly estimated the amount of fuel that would be needed, and, as a consequence, used up the fuel supply they had arranged for the day
- A lack of price differential between on- and off-peak periods reduced incentives for pumped-storage hydro facilities to pump overnight, which reduced energy storage and led the ISO to posture pumped-storage units extensively.

Limited Energy Generation resources

Several gas resources increased their use of the Limited Energy Generator (LEG) provisions in the market rules, which further reduced generator availability and forced the ISO operators to take on more fuel management responsibilities. In essence, these rules allow resources to limit their operation when they have limited fuel. Subsequent to receiving a Day-Ahead commitment, these gas resources informed the operators that they had limited gas and could not operate beyond what was committed in the Day-Ahead market. Thus, the operators could not use the additional stated capability of the unit to address system needs.

While it is valuable to system operators to know if a generator has limited fuel, the ISO is concerned with significant increases in the use of LEG provisions by natural-gas-fired generators because it adds significantly to the complexity of system operations, particularly during the types of operating conditions that occurred this winter. For example, the amount of generating resources that operated as limited energy generation on February 9 represented twice the usual number of LEG units and nearly three times the usual number of LEG hours and megawatt-hours.

Availability of oil-fired generation

While oil-fired generation provides valuable fuel diversity to the region, many oil-fired generators today maintain limited fuel inventories and may not be able to sustain operation as needed during a period when gas supplies in the region are tight, particularly if the operation period is sustained over multiple days during adverse weather conditions that interfere with oil resupply.

The ISO conducts periodic fuel surveys and the oil inventories reported to the ISO by generators suggest that many oil tanks are, on average, kept only about one third full. This may be adequate inventory for the limited hours that oil units are dispatched during the year (oil-fired resources make up less than one percent of the total electric generation annually), but it limits the availability of these resources when needed by the ISO. For example, if approximately 12,000 MW of resources that are capable of operating on oil were operated at full load, almost half of those resources would become unavailable after 48 hours, assuming no replenishment of fuel inventory. See Figure 3. Estimated Oil-Generator Output from Fuel Surveys.

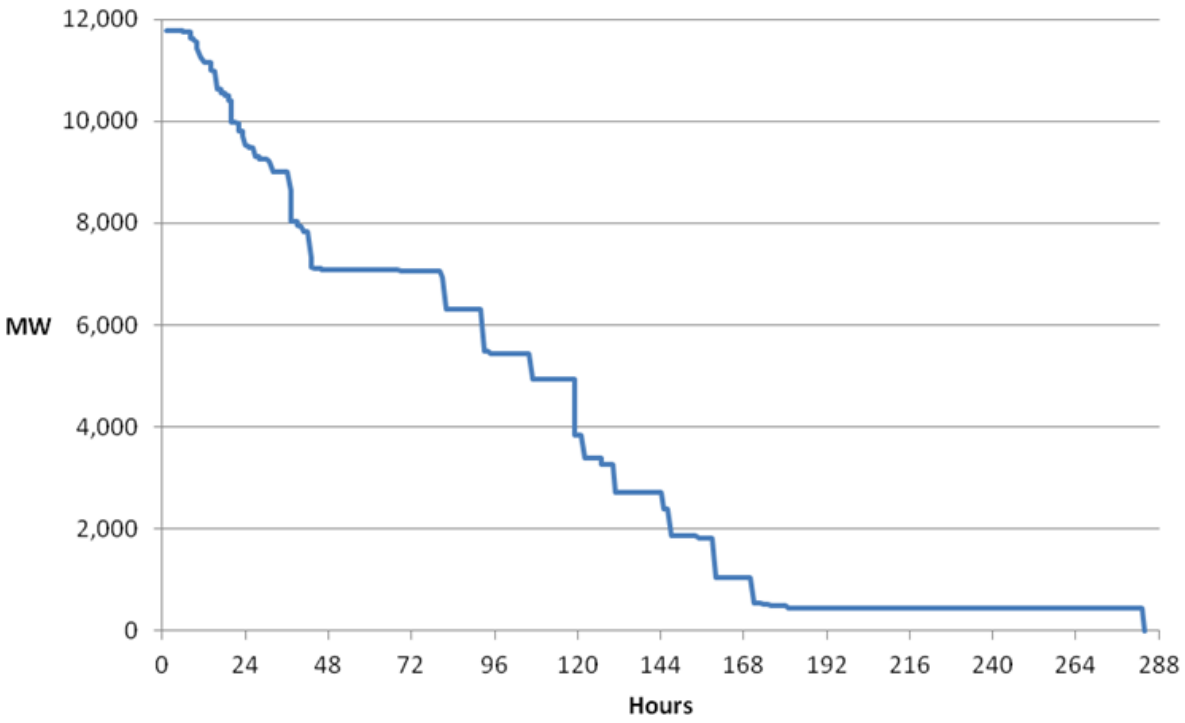

Figure 3. Estimated Oil-Generator Output from Fuel Surveys

February 8-9, 2013

The following are highlights of the ISO's preparations for the February blizzard and the operating challenges that followed.

Highlights of ISO preparations:

- ISO held daily conference calls with Local Control Centers (LCCs), the Northeast Power Coordinating Council, gas pipelines, nuclear plants, and the National Oceanic and Atmospheric Administration
- ISO postponed or cancelled generator and transmission outages
- ISO contacted generators to check fuel supplies
- LCCs contacted black-start units to check fuel supplies
- ISO arranged additional staffing at Main Control Center and Backup Control Center

Operating challenges:

- The loss of non-gas-fired generation (e.g., a large oil plant that was out-of-service due to Superstorm Sandy, a nuclear plant, and a large coal plant taken out of service by the blizzard), increased the reliance on gas-fired plants and exacerbated concerns related to the inflexibility of fuel supply to natural-gas-fired generating facilities.
- A lack of flexibility of fuel supply for gas- and oil-fired generators may not provide system operators with the ability to alter the dispatch of the system within the time needed to maintain system reliability.
- During the overnight period from Friday, February 8, through early Saturday morning, February 9, more than half a dozen generators informed ISO system operators that they could not get gas. It appears that the primary reason was that these generators had not made forward gas

procurement arrangements before the weekend (i.e., before the gas-supply market closed earlier on Friday), and were relying on the procurement of "spot" gas if called to run by the ISO. Given that the gas-supply market is largely illiquid during evening and weekend hours, it became extremely difficult to source gas during these hours.

- A loss of more than 2,000 MW of generation in the Southeast Massachusetts/Rhode Island (SEMA/RI) area made it difficult to manage system security in Rhode Island and New England west-to-east power-system transfers.
- The operator of a large resource in SEMA/RI asked ISO system operators to intervene on the plant's behalf with the interstate pipeline so they could obtain fuel.
- Transmission outages started around 7 p.m., Friday, February 8, and peaked after midnight, mostly from high winds and snow-packed substation equipment, affecting both 115 and 345 kilovolt lines.
- LNG supplies are dynamic and the ISO does not have access to information about available supplies, other than monitoring publicly-available information. This creates additional uncertainty as to the availability and timing of releases of LNG into the New England gas pipeline system.

More than 6,000 MW of gas- and oil-fired generating capacity became unavailable on Saturday, February 9, either because of storm-related outages or because of the uncertainty of their fuel supply. See Figure 4. Generator Outages and Reductions.

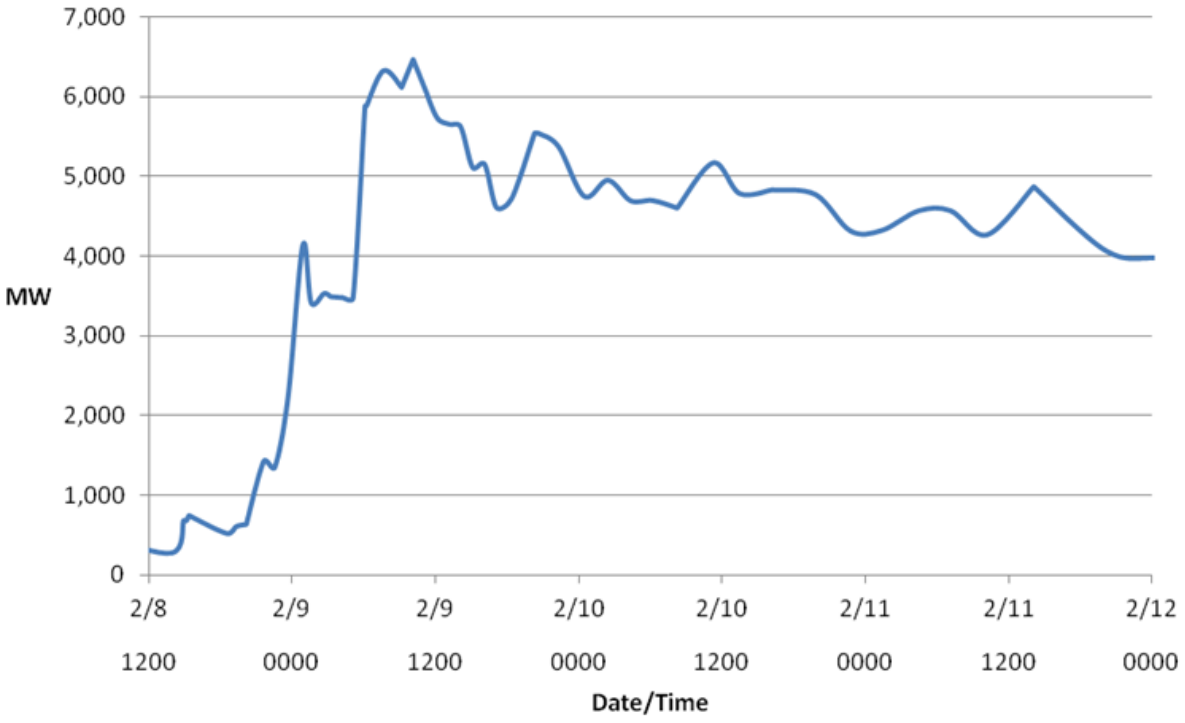

Figure 4. Generator Outages and Reductions

Section 4. Tight reserve margins during the week of January 21

ISO New England is required to carry operating reserves to respond to a loss of any resource on the power system, such as when a large generator trips offline unexpectedly. Operating reserves enable system operators to keep the lights on even if a large supply resource suddenly becomes unavailable. The total operating-reserve requirement in New England is approximately 2,200 MW.

Reserve margins became razor thin over the evening peak on January 21, 2013, the first day of a five-day cold stretch. The reserve margin stayed within required levels, but it is important to understand that the electric system is extremely vulnerable immediately following contingencies during these situations when the weather is cold and gas-supply margins are tight. The ISO's system operators can face significant challenges identifying additional resources to cover the load and the operating-reserve requirement when other resources suddenly become unavailable. A large single-source contingency on the power system at times such as this could put the region immediately into a reserve shortage and cause the activation of multiple steps of procedures to manage capacity deficiencies (i.e., Operating Procedure No. 4, *Actions During a Capacity Deficiency, or OP4 actions*), or more serious actions, including controlled power outages (i.e., load shedding). See Figure 5. Reserve Margins.

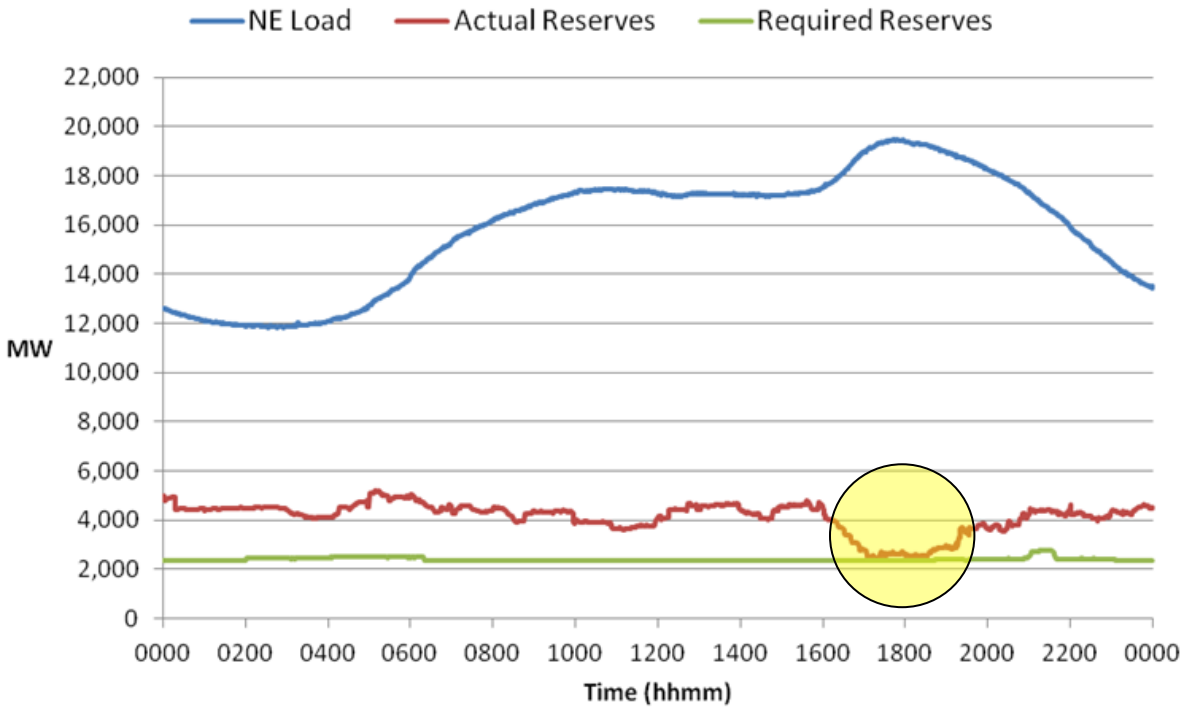

Figure 5. Reserve Margins

The amount of operating reserves increased during the remainder of the five-day cold stretch—and always stayed within required levels—but the volatility of operating conditions continually threatened the need for additional actions to maintain reserves. These actions included continually re-dispatching the system, committing additional generation (i.e., supplemental commitments), and the potential need for OP4 or other actions.

OP4 actions were, in fact, required on January 28 to manage a tight capacity situation in the days immediately following the stretch of cold weather as generator availability continued to be challenged by fuel-supply issues. For example, some gas-fired generating resources were called for dispatch in the overnight period to offset the loss of other fuel-constrained resources, but their unexpected operation reduced their available gas supplies, which, in turn, made them unavailable for dispatch during the morning load ramp the next day. This reduced the available capacity to cover operating reserves and triggered the OP4 actions to help maintain operating reserves. The ISO called on demand resources as one of the actions to provide the needed capacity.

Section 5. Fuel-supply challenges during the February storm

In the overnight period from Friday, February 8, to Saturday, February 9, while the blizzard was bearing down on the region, system operators were lining up resources to run the next day. During that time, system operators received the following types of updates from several generators:

- Plants have only a few days of oil left and for some, deliveries were suspended because of the storm
- Plant will plan to switch the unit from oil to gas at midnight, but only procured enough fuel to run at economic minimum (ECOMIN) through the weekend, not available on gas at full output
- Plants are having difficulty procuring natural gas during overnight hours
- Plant does not have enough gas to run at the requested output level
- Plant is running out of oil and needs to shut down
- Plant(s) start-up is delayed because of storm conditions

Additional measures

In addition to communicating with plant operators, ISO system operators and management coordinated emergency calls with management of generating companies and pipelines to allow the generating resources to continue to operate for power system reliability while the resource attempted to arrange for supply through the overnight hours or first thing in the morning.

In addition to reliably operating the electric grid through an extreme weather event, the ISO had to actively manage fuel inventories of certain power plants during the storm. Figure 6 highlights some of the key electric system and fuel-supply challenges that occurred in the overnight period during the February blizzard. The ISO's system operators normally line up generation during the overnight period for the next day's morning load ramp. However, during the blizzard, system operators encountered numerous generating resources that were unavailable due to a variety of fuel-related issues, including natural-gas-fired and oil-fired facilities.

Section 6. Challenges of the winter load profile

Beyond managing the challenges of the morning load ramp-up, system operators faced a very sharp ramp-up toward the late afternoon peak on Saturday, February 9. The load can ramp at a rate of 20 to 40 megawatts (MW) per minute—or the equivalent of nearly 1,200 MW/hour.

The winter load peaks twice each day: first in the morning-to-noon timeframe and then as a higher peak in the late afternoon-to-evening timeframe (unlike the summer which only has one daily peak in the afternoon). In the winter, the peak persists for a relatively short period of time and operators then face a very sharp ramping down of load. By comparison, the load in the summer (while significantly higher than the winter) builds gradually over many hours in the day, lingers across a longer peak, and ramps down gradually and earlier in the day. Weather (such as temperature and humidity) and the number of daylight hours are key factors that affect the daily system load profile throughout the year.

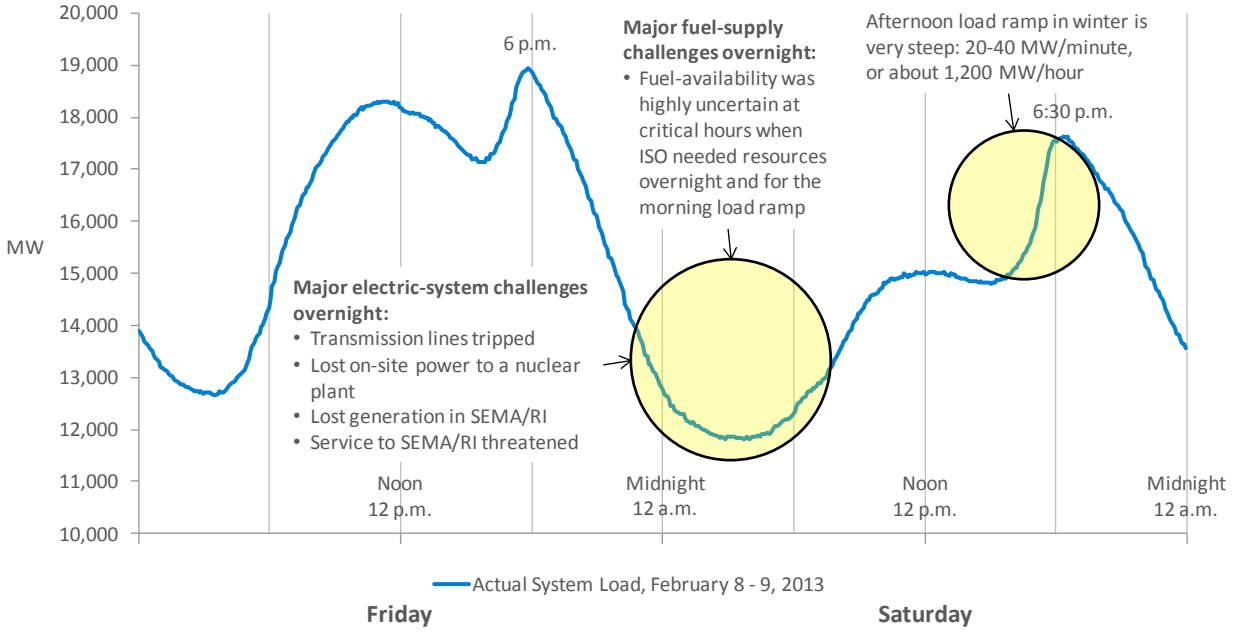

Figure 6. Challenges in the Overnight Period, February 8-9

Section 7. Energy prices in New England

Wholesale electricity prices in New England dropped significantly in 2012 compared with 2011 as lower-priced shale gas entered the marketplace, but energy prices have increased this winter. Two key factors are driving the increase.

First, interstate pipelines that deliver fuel to the region from the west and south have been running at capacity, which limits the flow of the most economic supplies of natural gas into the region. This has driven up natural gas prices, and has, in turn, driven up wholesale electricity prices. Second, the ISO has needed to commit significant amounts of additional generating resources for reliability, which adds to wholesale electricity costs.

Fuel prices and electric-energy prices

Natural gas price indices, which have been about $4 per million British thermal unit ($/MMBtu) across much of the country, increased to $35/MMBtu in New England in January. Intra-day trades actually occurred at higher price-thresholds. These higher prices have directly affected wholesale electricity prices in New England where more than half the region's electricity is produced by natural-gas-fired generating resources. Wholesale electric-energy prices in New England increased more than 100% in January and more than 300% in February compared to 2012.

In some cases, oil-fired generating resources have been economic to run in the region's energy market because of the high natural-gas prices (unlike most of the time when high oil prices make oil-fired generators uneconomic in the market). However, the favorable economics for oil resources have reduced the fuel inventories of these resources and limited their availability when called upon by the ISO when the natural-gas system is constrained, which has created challenges for system operators.

Figure 7 shows the increase in wholesale electricity prices in the day-ahead energy market over the last 14 months (through February 20, 2013).

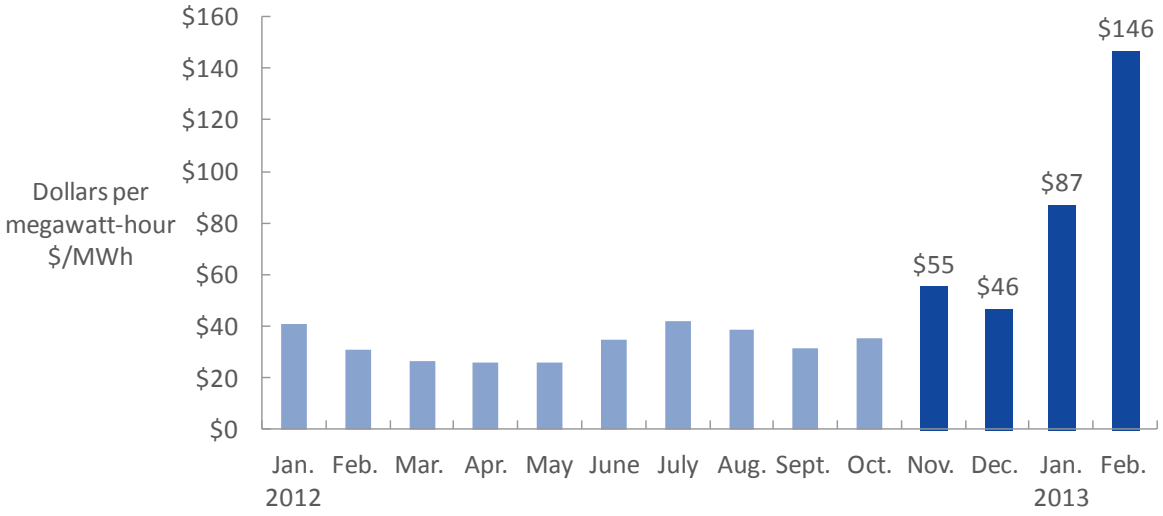

Figure 7. Wholesale Electricity Prices, Jan 2012 - Feb. 2013

Preliminary data shows that the total value of the wholesale energy markets in the timeframe from January 1 to February 20, 2013, is estimated to be about $2 billion. (In comparison, the value of the energy market totaled about $5 billion in 2012.) The January and February 2013 figures will be updated after the final settlements for these months are released.

U.S. Department of Energy spotlight on energy prices

These energy-price phenomena were highlighted in two recent reports by the U.S. Department of Energy. On January 18, the U.S. Department of Energy (U.S. DOE) issued a Short-Term Energy Outlook Supplement indicating that constraints in New England are likely to affect regional energy prices this winter. DOE's outlook noted that since November, New England has had the highest natural gas prices in the U.S. Then on January 25, U.S. DOE issued a Northeastern Winter Natural Gas and Electricity Alert, reporting that natural gas prices had reached $35/MMBtu in New England while prices remained below $4 in the rest of the country. U.S. DOE indicated that natural gas prices had become high enough in New England that some oil units would be economic to be dispatched in the region's wholesale electricity market.

Out-of-market payments to resources needed for reliability

Payments to generating resources committed for reliability increased to $22 million in January and to $44 million in February 2013.[2] (In comparison, reliability payments for all of 2012 totaled $87 million.) These payments represent 2% of the total energy market in January, and 4% in February. (Data is through February 20, 2013.)

Infrastructure affects prices paid by consumers

New England consumers are paying higher prices for energy (natural gas and electricity) than consumers in other parts of the country largely because of a lack of infrastructure to deliver the lowest-priced

[2] Total consists largely of Net Commitment Period Compensation (NCPC) first and second-contingency payments.

supplies of natural gas into the region. Because many retail customers in the region pay fixed prices for electricity through either a competitive supplier or a default-service provider, they may be shielded from the immediate effects of these constraints; however, as contracts with suppliers are renewed, suppliers are expected to price the higher cost of natural gas into their contracts to sell electricity to retail customers.

The ISO, together with its stakeholders, is considering changes to the incentive structure in its wholesale market design in order to strengthen the incentives for generators to make adequate fuel arrangements and provide the ISO with the operating flexibility that is required, particularly under stressed power system conditions. These market rule changes will cause generators to include the costs of responding to these incentives in their offers, likely causing an increase in wholesale electricity prices, which over time will result in additional fuel infrastructure and increased operational flexibility as generators make operational adjustments, including seeking more secure and more flexible fuel services in the market place.

Outside of the changes to the wholesale markets, policymakers and regulators in New England are evaluating solutions from an infrastructure perspective. The ISO understands that policymakers and regulators will weigh the benefits and costs of infrastructure options to relieve natural-gas transmission bottlenecks into the region, thereby increasing access to competitive supplies of natural gas available in New England's own backyard, and also strengthening fuel security for the region's growing dependence on natural gas for power generation.

Section 8. Key observations

- **Recent operating conditions are unsustainable**—The region's growing dependence on natural gas for power generation is a rapidly-escalating strategic risk for the region. ISO New England system operators must manage the power system in the face of growing uncertainty about the fuel supply for natural gas- and oil-fired generating resources—a condition that is unsustainable.
- **Conditions could have been worse**—Sustained cold temperatures or high demand for electricity—had these conditions occurred this winter—would have exacerbated the challenges of operating the power system in New England at a time when season-long fuel-supply constraints and a blizzard converged to severely test the reliability of the system. If New England had experienced sustained cold weather in the period immediately following the January 21–25 cold-weather event, the reliability of the region's power system would have been even more threatened because oil and LNG inventory levels had been significantly depleted.
- **Challenges worsen overnight and on weekends**—The structural mismatch between the 24x7 demands of the electric system, and the less-liquid, overnight and weekend market for gas supply creates additional uncertainty in the commitment and dispatch of gas units during overnight and weekend hours.
- **Lack of secure fuel arrangements reduces region's "excess" capacity**—The region has excess capacity, however, the lack of secure fuel-supply arrangements and the unavailability of resources for other reasons reduced the available capacity sharply during this cold-weather period, as indicated by the tight reserve margins.
- **Natural gas prices at a premium in New England**—Natural gas prices reached $35 per million British thermal unit ($/MMBtu) in New England in January while prices remained below $4/MMBtu in the rest of the country. High natural gas prices in New England—driven by pipeline constraints into the region from the west and the south, and the use of globally-priced LNG—drove wholesale electricity prices up more than 100% in January and more than 300% in February, compared with 2012.
- **Wholesale electricity prices tracking high gas prices**—Preliminary data shows that the total value of the wholesale energy markets in the timeframe from January 1 to February 20, 2013, is estimated to be about $2 billion. (In comparison, the value of the energy market totaled about $5 billion in 2012.) The January and February 2013 figures will be updated after the final settlements for these months are released.

Section 9. Conclusions

This winter has demonstrated that New England's natural-gas dependency risk is escalating rapidly and that the current fuel arrangements of generators, including the structural inflexibility of the fuel delivery systems for oil and gas, is leading to extremely vulnerable and likely unsustainable operating conditions when the power system and fuel-supply chains are stressed. The ISO has documented the risk for more than a decade through numerous reports and studies and in the past few years has identified it as the highest-priority strategic risk for the region. This risk is not isolated to extreme cold weather events, or even to winter events. The challenges—which are most acute during the winter—are showing up in real-time system operations on an ongoing and year-round basis and will threaten the reliability of power system for the six-state region if not addressed in a timely manner.

In addition to the longer-term market-design changes proposed for the Forward Capacity Market, immediate solutions are needed to avert serious threats to system reliability – both for next winter and until the longer-term design changes take effect.

Section 10. Next steps

ISO New England is continuing to meet with the states and other New England stakeholders to discuss these challenges and solicit input on potential solutions.

The ISO will work with its stakeholders to develop a set of immediate solutions that can be in effect for winter 2013–2014. The ISO plans to file the proposed solutions with the Federal Energy Regulatory Commission by this summer. The exact solutions have not yet been identified, but the ISO's goal is to develop immediate solutions that can be implemented simply and quickly.

This filing of short-term solutions will be *in addition to* filing a set of long-term solutions later in the year, which will include a proposal to strengthen the performance incentives in the Forward Capacity Market.