# An Assessment of Heating Fuels And Electricity Markets During the Winters of 2013-2014 and 2014-2015

October 2015

Office of Electricity Delivery and Energy Reliability
U.S. Department of Energy

*This page intentionally blank*

## For Further Information

This report was prepared under the auspices of the Energy Infrastructure Modeling and Analysis (EIMA) division of the Office of Electricity Delivery and Energy Reliability (OE). OE's vision is a U.S. energy delivery system that is reliable in the face of all hazards and resilient to disruptions, supports U.S. economic competitiveness, and minimizes impacts on the environment. EIMA's mission is to ensure the reliability and resiliency of U.S. energy infrastructure and systems through robust analytical modeling, and assessment capabilities to address energy issues of national importance. The Division is focused on conducting risk analyses and predictive modeling, and providing analytical products intended to inform decision makers at the public and private levels.

ICF International provided technical support in the preparation of this report. Specific questions may be directed to Alice Lippert, Senior Technical Advisor, EIMA Division (alice.lippert@hq.doe.gov). For more information regarding the EIMA Division, please contact energyanalysis@hq.doe.gov.

*This page intentionally blank*

# Preface

Cold weather that blanketed much of the Eastern United States in 2013-2014 and 2014-2015 exhibited unique characteristics that prompted different — but related — challenges across heating fuels and electricity markets.  In an effort to understand the impacts of the winter conditions on these markets, the United States Department of Energy, Office of Electricity Delivery and Energy Reliability, conducted an in-depth analysis of regional fuel and electricity sectors during the winters of 2013-2014 and 2014-2015 to assess market behavior and performance. Particular attention was devoted to events in the Northeast and Midwest regions, where prolonged periods of cold temperatures and severe winter weather had strong effects on energy market prices, demand and supply.

Events, trends, and market stressors highlighted in this report provide insight into the experiences and actions taken by private and public sectors in response to the severe weather during the winters of 2013-2014 and 2014-2015  These responses can help inform policy decision makers and energy market participants for future winters.

*This page intentionally blank*

# Table of Contents

## LIST OF TABLES



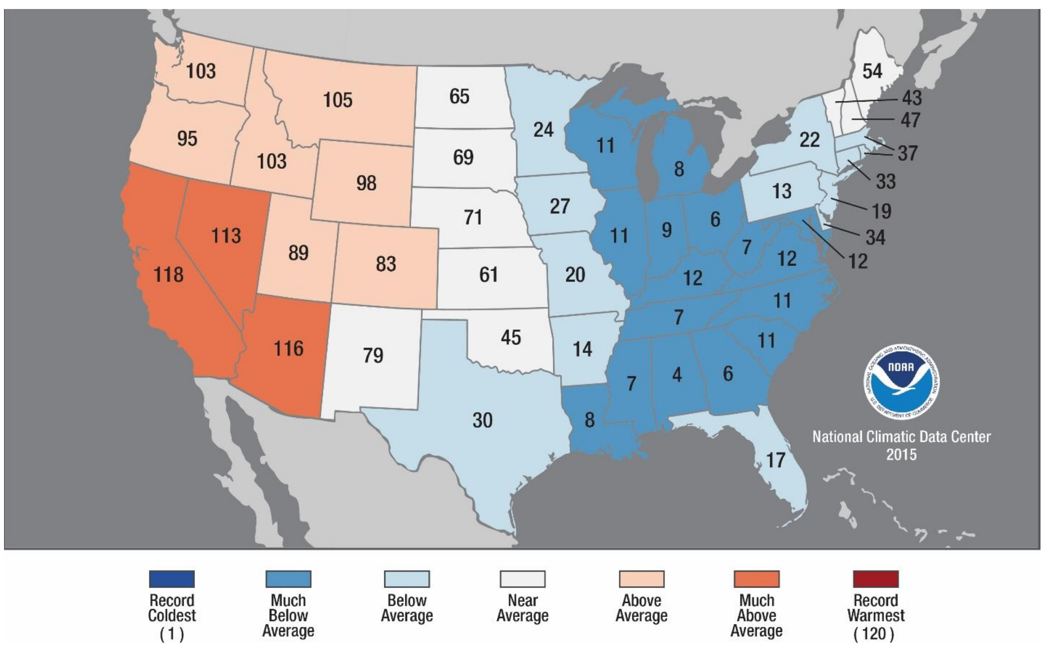
## LIST OF FIGURES

# Executive Summary

The winter seasons of 2013-2014 and 2014-2015 were among the coldest in recent history in much of the Eastern United States. These winters — defined as October 1 through March 31 of the respective years — were marked by prolonged periods of below-normal temperatures, severe storms, and other weather events that disrupted the energy supply and delivery systems. Figure ES-1 shows the severity of the cold temperatures during January 2014.

This report examines the behavior and performance of the fuel and electricity markets in response to these severe winter events. It focuses specifically on heating fuels which include propane, natural gas, and distillate fuel oil.[1] Electricity markets are also examined, given some regions' reliance on electricity for space heating and the interdependencies that exist between electricity and other heating fuels (since heating fuels may also be used for electricity generation.)

*Figure ES-1 Statewide Average Temperature and Temperature Rank (Coldest to Warmest), January 2014*




This map shows the average winter season temperature slotted into bins of "Near Average," "Below Average," etc. The number is the rank in terms of coldest to warmest January over the period 1895-2014. For example, during January 2014, Virginia experienced weather that was Much Below Normal and was the 12th coldest January over the 1895 to 2014 time period. Source: National Temperature and Precipitation Maps, National Centers for Environmental Information, National Oceanic and Atmospheric Administration (NOAA). Accessed August 1, 2015: http://www.ncdc.noaa.gov/temp-and-precip/us-maps/1/201401?products[]=statewidetavgrank.

[1] Definitions of terms for specific fuel types, regions, trading hubs, and other terms of art are provided in the text and footnotes to the main body of the report and the glossary, but omitted from the executive summary.

All regions of the United States were examined in the course of preparing this report, but the greatest attention centers on the Northeast and Midwest regions, where cold weather had the greatest impacts on prices, demand,[2] and supply.[3]

Cold weather that blanketed the Northeast and Midwest in 2013-2014 and 2014-2015 exhibited unique thermal, geographic, and timing characteristics that prompted different — but related — challenges across fuels and electricity markets.

## Heating Oil and Distillate Fuel Oils

Near record cold temperatures during the winters of 2013-2014 and 2014-2015 contributed to tight supplies of heating oil. These effects were particularly pronounced in the New England and Central Atlantic regions, where heating oil is the primary fuel for space heating in 39% and 18% of homes, respectively. Coinciding high electricity demand, high gas prices, and limitations on the availability of pipeline gas supply led to an increase in distillate fuel oil demand by power plants that have the ability to switch fuels from natural gas to fuel oil.

Increased demand, coupled with lower distillate stock levels in the Northeast since the winter of 2012-2013, led to dramatic price increases. Spot distillate fuel oil prices traded more than 80 cents per gallon ($33.60 per barrel) above Brent crude oil for brief periods in both February 2014 and March 2015 — double the spreads typically seen at the beginning of each winter and significantly above previous winter peaks. See Figure 2-3 for further analysis. The higher spot distillate prices directly impacted consumers through higher residential heating oil prices. In addition, the extreme cold in the Northeast in early 2015 caused operational problems at regional refineries and froze rivers and waterways, inhibiting the marine transport of heating oil to some marine-dependent markets and further driving up prices.

Despite these challenges, demand for heating oil in Northeast markets was met in both winters, as the U.S. Coast Guard worked diligently to keep critical marine routes open and a combination of stock drawdowns and import cargoes made up for disruptions in refinery supply of distillate fuel oils. Furthermore, heating oil prices in all classes of trade (spot, wholesale and retail) in winter 2014-2015 fell substantially due to a sharp decline in global crude oil prices over the second half of 2014, which fortuitously limited the overall price impacts on consumers of the spikes that did occur.

## Propane

Propane is widely used throughout the United States for a variety of purposes, but is particularly important as a residential space heating fuel in the Northeast and Midwest. Demand for propane soared during the winters of 2013-2014 and 2014-2015 due to the cold

---

[2] In economic theory "demand" is the desire for a good at a given price and "consumption" is the actual quantity used. In this report, references to demand and consumption are used interchangeably. For some energy sources, consumption or demand can be directly measured but for others proxy measures must be used. This is explained further in the report.

[3] Energy markets, particularly power, oil, and propane, define geographic regions in different ways. For consistency, geographic references in this report generally correspond to U.S. Census regions, except where otherwise noted. For the electricity market, regional data tracks the four most affected Independent System Operators (ISOs) / Regional Transmission Organization (RTOs): New England, New York, PJM, and MISO.

temperatures. During the 2013-2014 winter, propane stocks in the Midwest were also drawn down by unusually high demand for grain drying that occurred later in the year than normal. At the same time, Midwest supply was limited during the 2013-2014 winter by infrastructure constraints, supply outages, and rail transportation interruptions. The winter also started with Midwest inventories at well below average levels.

In the Northeast, demand similarly jumped in the winter of 2013-2014, as seen in consumption levels that set records compared to the previous five winters. However, Northeast supply dynamics adjusted somewhat more than in the Midwest to meet peak demand, due to the availability of marine imports from Western Europe in addition to increased imports from Canada. So, while prices saw significant spikes, there were relatively fewer supply challenges.

Propane supplies were tight in the winter of 2013-2014, resulting in economic impacts on consumers and companies. Higher fuel prices created economic hardship, and some customers were priced out of the market. In addition, many propane marketers were forced to only partially fill some customer propane storage tanks in order to ensure sufficient inventory to meet other customer requirements. Many smaller propane marketers reached their credit limits — which constrained their ability to replace propane inventories. There were reports of propane companies failing to deliver propane to customers that had, prior to the increase in market prices, signed fixed price delivery contracts. Some propane companies had to give priority to hospitals and residential consumers to ensure delivery to their highest-need customers. In response, state and federal agencies undertook urgent actions to increase supply access, including issuing hours-of-service waivers for truck drivers to move propane supplies into the areas of shortage. The Federal Energy Regulatory Commission (FERC) exercised its emergency powers to require prioritization of propane pipeline shipments to help alleviate the shortage of propane supplies.

Such impacts did not occur in the winter of 2014-2015. The collapse in crude oil prices in the second half of 2014 constrained prices overall. In the Midwest, growth in natural gas liquids production brought stocks well above the previous five-year average, grain drying demand during the fall was much lower than in the previous year, high demand periods were not as continuous, and there were no major unexpected facilities outages. In the Northeast, production in the Marcellus and Utica shale plays increased, contributing to supply.

### Natural Gas

While natural gas demand normally peaks during winter months due to increased gas use for space heating in residential and commercial buildings, the cold weather during the 2013-2014 and 2014-2015 winters pushed residential and commercial consumption 15% and 10% higher than average, respectively. The natural gas system was adequate to meet this "firm demand" surge, in the sense that residential and commercial customer heating demands were met.

However, supply for the power sector typically operates on "interruptible" contracts, where pipeline capacity is released on days when firm customers are not using their full contracted capacity. The growing share of power generation from natural gas and the fact that electricity demand tends to increase on very cold winter days led to temporaneous demand for natural gas and electricity, creating even higher natural gas demand and challenges to the power sector (see Natural Gas chapter).

Thus, during the winter of 2013-2014, demand significantly elevated U.S. spot prices for natural gas. Prices at Henry Hub (generally considered to be indicative of overall U.S. price trends) averaged $4.44/MMBtu, about 25% higher than the prior 12-month period. The highest and most volatile prices occurred in the Northeast and Midwest, where several pipelines issued critical notices and operational flow orders (OFOs) to prevent system imbalances: spot prices in New York City averaged over $10/MMBtu and spiked to a daily record high of $121/MMBtu. It is notable that prices in the Marcellus Shale production area averaged just over $4/MMBtu and peaked at only $8.46/MMBtu. The price differentials between the Marcellus Shale and nearby market areas along the East Coast demonstrated the effect of pipeline constraints between the two areas on high-demand days. See Table 4.1 for further analysis. However, pipeline constraints were not the only price driver; the severely cold weather also caused well freeze-offs in the Marchelles shale area, limiting production.[4]

Prices during the winter of 2014-2015 were lower in most markets than in 2013-2014. Henry Hub price peaked around $4.50/MMBtu in November 2014, but hovered around $3/MMBtu for most of the winter. When daily price spikes did occur in the Northeast and Midwest, they were not as high as in the previous winter. The lower prices and reduced price volatility were due to a combination of factors. These included the fact that the periods of cold weather during the winter of 2014-2015 were neither as long in duration nor as widespread as during the previous winter; there was increased domestic gas production, mostly due to growth in output from the Marcellus Shale; and there was much milder weather in December, so early season gas storage withdrawals were relatively low. In addition, preemptive measures were taken prior to the winter of 2014-2015, which helped moderate average prices and dampen daily price volatility: for example, ISO New England expanded its Winter Reliability program, which increased the availability of fuel oil to produce electricity in times of high demand.

## Electricity

The weather conditions during the winters of 2013-2014 and 2014-2015 had particularly adverse effects on power markets in New England, New York, and the Mid-Atlantic and Midwestern United States.[5] Periods of extreme cold led to abnormally high demand for natural gas in both the heating markets and electric generation markets in both winters. This led to constrained pipeline capacity to meet non-firm needs and spikes in natural gas prices. Because natural gas is the marginal fuel used for electricity generation in these regions, wholesale electricity prices are closely correlated with natural gas prices.

As a result, real-time prices in New England reached $188/MWh (on peak) in January 2014, nearly three times the previous 5-year average peak price. Prices remained high in February, reaching $179/MWh, in contrast to $65/MWh for the 5-year average peak. In PJM's Western trading hub, rates peaked at $161/MWh in January, more than three times the previous 5-year average, and fell to $81/MWh in February, twice as much as the 5-year average. New York prices during the same time periods also doubled from the year before, while in the Midwest

---

[4] Energy Information Administration. *Cold weather led to record-high natural gas storage withdrawals*. January 17, 2014. http://www.eia.gov/todayinenergy/detail.cfm?id=14651&src=email

[5] For the electricity market, regional data tracks the four most affected Independent System Operators (ISOs) / Regional Transmission Organization (RTOs): New England, New York, PJM, and MISO.

the aggregate price levels were less dramatic but the percentage increases were substantial. See Figure 5-1 for a full analysis of real time on-peak electricity prices ($/MWh) in ISO-NE, NYISO, PJM, and MISO in January and February, 2014 and 2015, compared to prior five year average.

However, the cold weather during the 2014-2015 winter had a much less significant impact on the power markets. This was partially due to more gradual temperature drops leading up to the peak demand days in some regions. In addition, industry participants took several preemptive actions, including: expanded pre-winter preparation and reliability testing, enhanced communication, and improved ways in which previous years' information was used. These measures coincided with a sharp decrease in global oil prices, making petroleum-fired generators attractive for economic dispatch. Greater distillate fuel oil availability also relieved pressure on the gas market, since dual-fueled generating units could economically transition to distillate fuel oil instead.

## Observations Across Markets

While the fuels and electricity sectors experienced a mix of effects during the two winters, there were several key shared trends that led to more pronounced challenges in 2013-2014 than 2014-2015.

- **Weather Severity and Pattern Drove Impacts—**Perhaps the most consequential market driver was the unique weather pattern in each winter. The weather was colder for more prolonged periods in the 2013-2014 winter than in 2014-2015. This exerted more pressure on markets, depleted stockpiles, and affected consumers to a greater extent. In addition, at times in 2013-2014, markets stretching from New England to the South Atlantic were plunged into colder-than-normal temperatures at the same time, reducing flexibility to manage disruptions and provide inter-regional assistance. By contrast, in 2014-2015, the winter began cold in the Northeast and Southeast regions and the Midwest, then moderated, followed by its coldest snap in February. The warmer stretch in the middle gave supply and stocks time to recover, leaving markets better prepared for the coldest period.
- **Cold Weather Was Not the Sole Cause of Market Disruptions—**While the winter of 2013-2014 was abnormally cold, four significant storms in January of 2014 caused disruptions in supply, changes in demand patterns, and increased demands for natural gas and fuel oil from power plants. The three week closure of the Cochin Pipeline, beginning November 30, 2013, affected Midwest propane supplies, as did high and late grain drying demand. Low inventories of distillate fuel oil inventories at storage facilities at the beginning of the winters reduced any cushion for demand and supply disruptions. It is clear that a confluence of factors increased the severity of market disruptions.
- **Lower Oil Prices Cushioned the Severity of Market Effects in 2014-2015 —**A common theme across fuels markets was the fortuitous effect of the precipitous drop in global oil prices in 2014. This alleviated price pressure for several fuels and made backup fuel oil-fired power generation more economically attractive for dispatch, mitigating electricity price impacts.

- **Disruptions Were Limited, But at a Cost—**While there were examples of limited supplies and serious challenges for suppliers, there were no widespread or protracted disruptions of services to firm natural gas consumers or power customers in either winter.[6] Residential fuel oil and propane consumers were also able to obtain supplies of heating fuel. This service continuity was achieved notwithstanding episodes of service outages at key fuels and power facilities. However, the power and fuels industries' ability to maintain service reliability during the challenging winter events came at a cost, with higher retail prices to consumers. Across all of the markets examined, price spikes — some to multiples of average winter levels — were a common theme.
- **Public and Private Sectors Responded in Real Time—**There were many examples in 2013-2014 of regulators and industry implementing measures to mitigate high prices and ensure fuel supply. During both winters, pipeline operators issued increased operational flow orders (OFOs), which can direct shippers to observe various gas receipt and delivery protocols. These OFOs reduce the flexibility that pipelines typically grant to shippers during periods of lower demand and help the pipelines ensure reliable service. Propane marketers "short-filled" some customer propane storage tanks. Both state and federal agencies undertook urgent actions to increase propane supply access, including issuing hours of service waivers for truck drivers to move supplies into the areas of shortage. FERC used its emergency powers for the first time ever to prioritize propane pipeline shipments. These actions are discussed in greater detail in Chapter 3.
- **Lessons Were Learned for the 2014-2015 Winter—**The experiences of 2013-2014 brought greater focus on planning and coordination between the power and natural gas industries. Power grid operators instituted improved incentives to have fuel oil/distillate stocks available for plants in the event of natural gas supply disruptions, and to draw on Demand Response resources. Gas buyers also increased purchases of international LNG imports into New England gas markets. Propane customers and dealers implemented plans that included adding storage capacity and building propane inventories earlier in the season. These measures likely significantly mitigated the effects of the 2014-2015 winter, and were a key component of the greater supply availability across markets with lower price impacts.

[6] According to NERC, only one Balancing Authority was required to shed firm load and it amounted to only 300 MW. Page iii. http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf

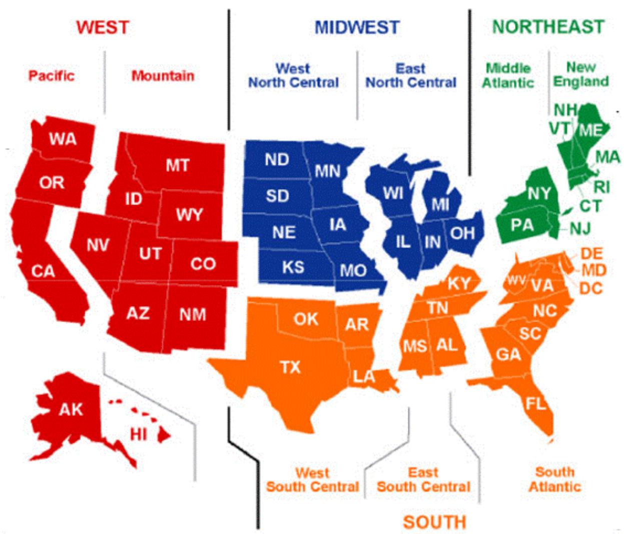
# 1. Introduction

The winter seasons of 2013-2014 and 2014-2015 were among the coldest in recent history. These winters — defined as October 1 through March 31 of the respective years — were marked by prolonged periods of below-normal temperatures, severe storms, and other weather events that disrupted the energy supply and delivery systems in parts of the United States. This report examines the behavior and performance of the fuel and electricity markets in response to these severe winter events. It focuses specifically on fuels used for space heating, including propane, natural gas, and heating oil. Electricity markets are also examined, given the reliance on electricity as a source for space heating in some areas of the country, and the interdependencies between electricity and heating fuels that are also used for electricity generation, such as natural gas and petroleum distillates.

The focus of this report is predominantly on the Northeast and Midwest regions of the United States because that is where the price, demand, and supply impacts were greatest, although other regions are examined for some fuels.

This chapter provides a synopsis of the weather conditions during the 2013-2014 and 2014-2015 winter seasons, and a brief overview of the space heating end-use markets. The remaining chapters discuss how the heating oil, propane, natural gas, and electric power markets performed under these severe weather conditions. Impacts on prices, consumption and supply are reviewed. In addition, extraordinary events that affected these markets are discussed for each of the energy sources. Temperature data and weather patterns described in this chapter are cited on the basis of Census regions as shown in Figure 1-1.

*Figure 1-1 Census Regions of the United States*

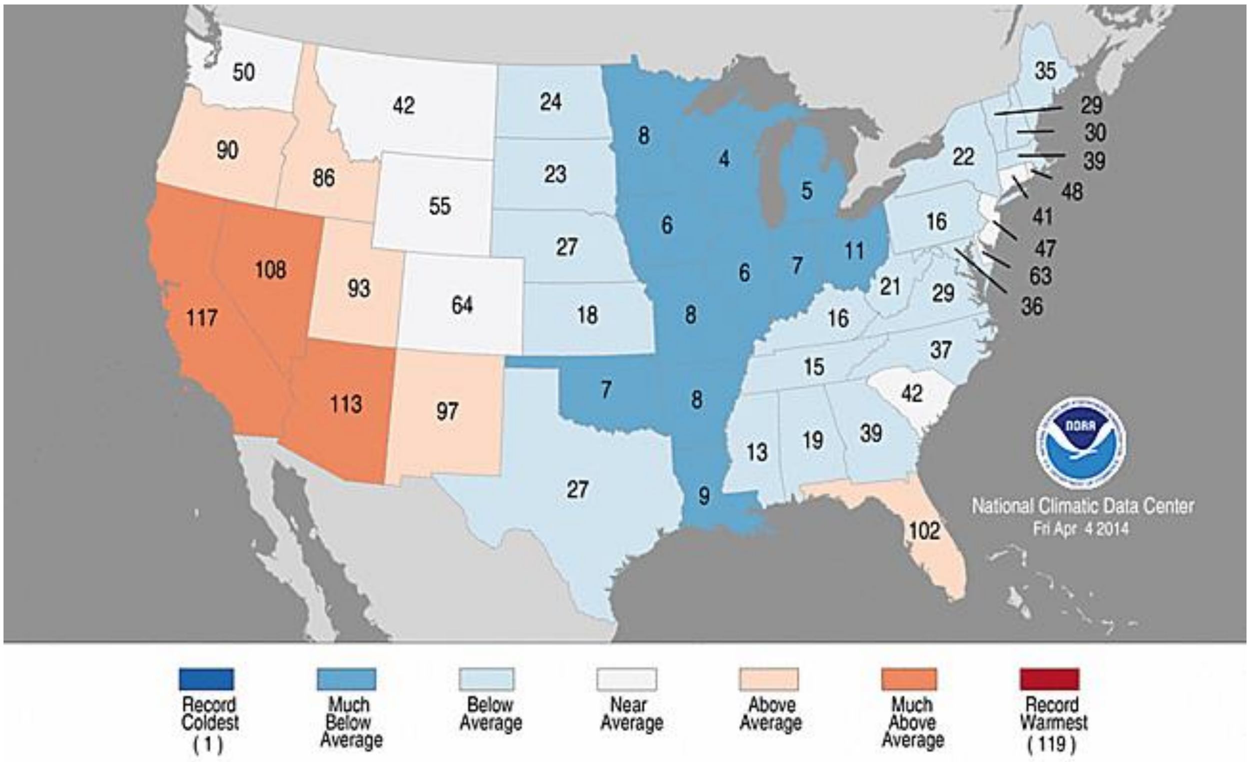



Source: Energy Information Administration. http://www.eia.gov/consumption/residential/reports/images/censusregionmap-lg.jpg

## The 2013-2014 Winter Season

During the winter of 2013-2014 much of the Eastern Seaboard experienced temperatures that were below average for the entire winter season, while the Midwest experienced temperatures that were *much* below average. In the western United States, temperatures were average or warmer than normal. Figure 1-2 illustrates the pattern of weather during the 2013-2014 winter season across the United States.

***Figure 1-2 Statewide Average Temperature and Temperature Rank (Coldest to Warmest), October 2013 – March 2014***




This map show the average winter season temperature slotted into bins of "Near Average," "Below Average," etc. The number is the rank of the winter season temperature, in terms of coldest-to-warmest over the period 1895-2014. For example, during the 2013-2014 winter South Carolina experienced weather that was Near Average and was the 42nd coldest winter over the 1895 to 2014 time period.

Source: National Temperature and Precipitation Maps, National Centers for Environmental Information, National Oceanic and Atmospheric Administration (NOAA), Average Period: 1895-2014. Accessed August 1, 2015: http://www.ncdc.noaa.gov/temp-and-precip/us-maps/6/201403?products[]=statewidetavgrank.

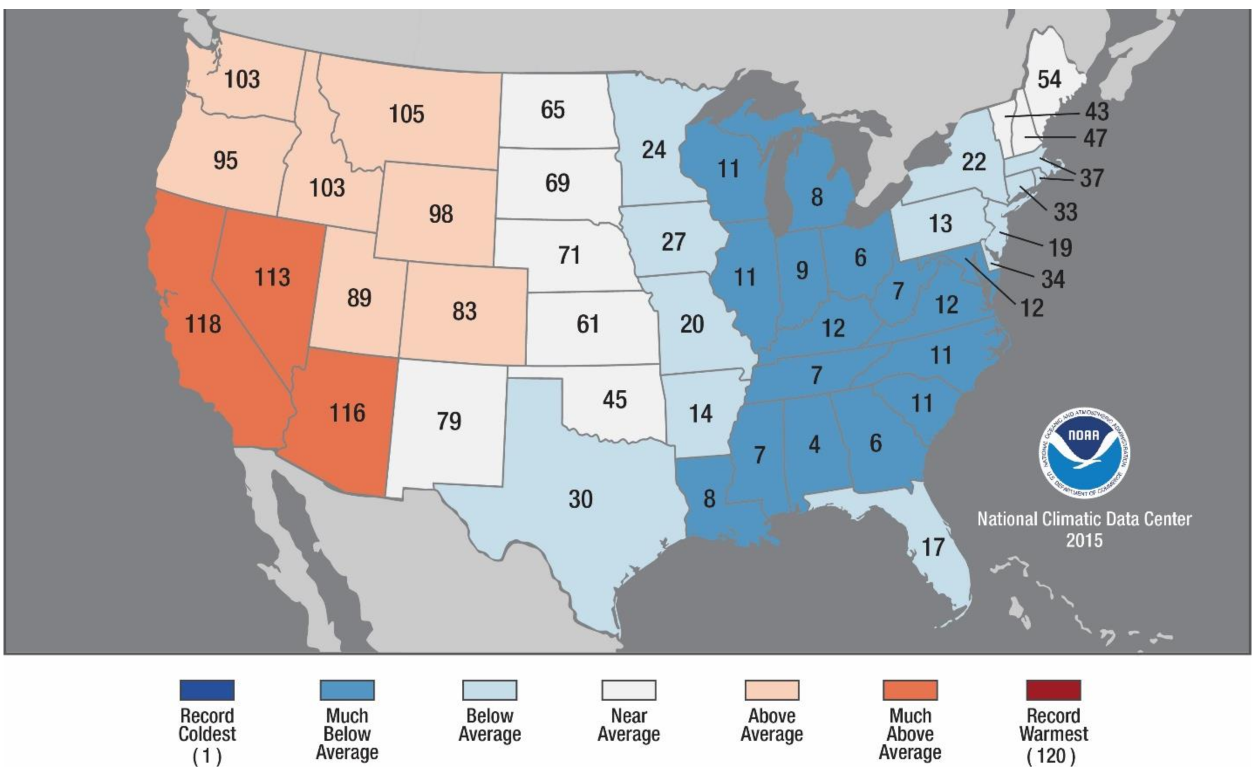
In the Midwest, many states experienced temperatures that ranked among the coldest recorded, some ranking in the top 10% of coldest temperature averages recorded since 1895. For example, Wisconsin and Michigan experienced the fourth- and fifth-coldest winters recorded since 1895. Figure 1-3 illustrates the state-level weather pattern for the month of January 2014, when weather conditions were most severe. As indicated, many states in the Eastern region of the United States experienced temperatures during this month that ranked in the 10-15% of coldest temperatures recorded since 1895. Table 1-1 illustrates the back-to-back weather events during this time period, January 2014, in the Eastern part of the United States.

*Table 1-1 Impacts of Winter Storms During January 2014*

| Date | Location Affected | Snowfall (ft.) | Other Impacts |
|---|---|---|---|
| **Jan 2-3** | Northeast, Midwest, Southeast | 1-2 | School closures, road closures, flight cancellations |
| **Jan 5-7** | Central, Northeast | 0.5 – 1 | Power outages, school and office closures |
| **Jan 21-22** | Southeast, Northeast, East North Central | 1 – 1.5 | Road closures, flight cancellations |
| **Jan 28-30** | Southeast, Mid-Atlantic | 0.25 – 1 | Massive road blocks and stranded commuters, school closures |

Source: NOAA National Centers for Environmental Information, State of the Climate: National Snow & Ice for January 2014, published online February 2014, retrieved on July 1, 2015 from http://www.ncdc.noaa.gov/sotc/snow/201401.

*Figure 1-3 Statewide Average Temperature and Temperature Rank (Coldest to Warmest), January 2014*



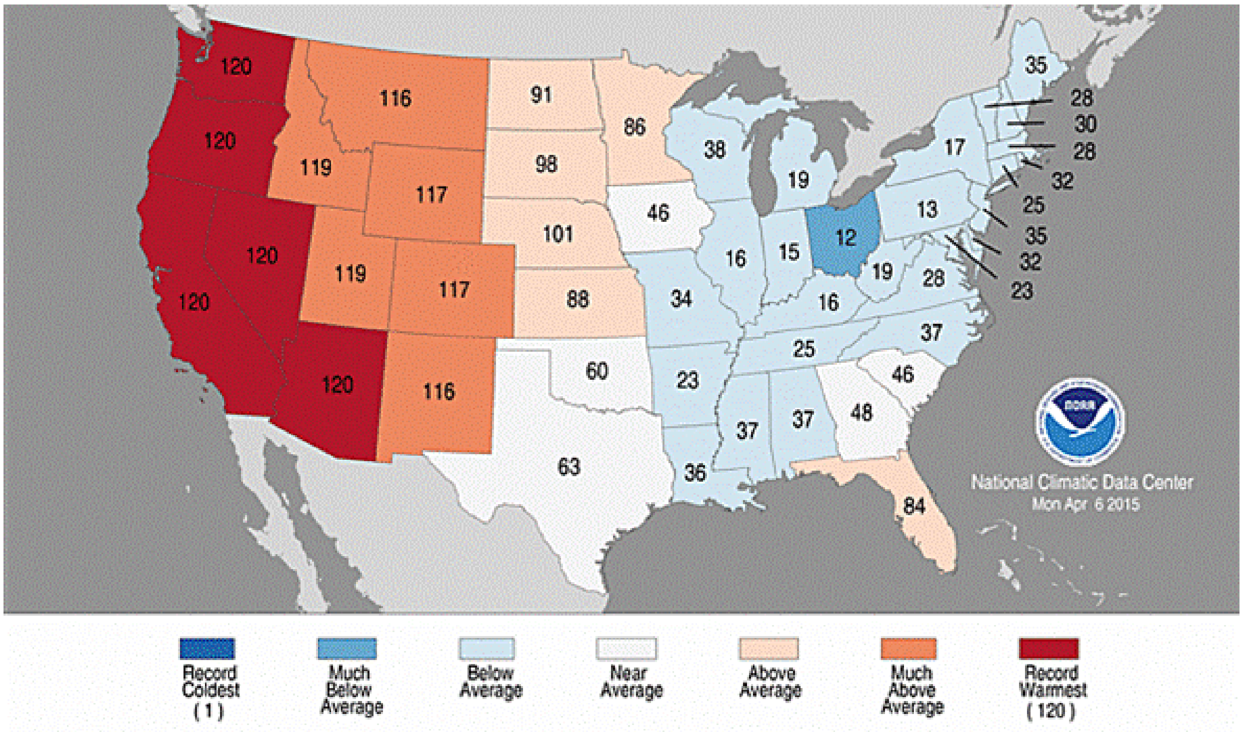

This map shows the average winter season temperature slotted into bins of "Near Average" "Below Average," etc. The number is the rank of the January 2014 seasons temperature in terms of coldest-to-warmest January over the period 1895-2014. For example, during January 2014 Virginia experienced weather that was Much Below Average and was the 12th coldest January over the 1895 to 2014 time period.

Source: National Temperature and Precipitation Maps, National Centers for Environmental Information, National Oceanic and Atmospheric Administration (NOAA), Accessed August 1, 2015: http://www.ncdc.noaa.gov/temp-and-precip/us-maps/1/201401?products[]=statewidetavgrank.

## The 2014-2015 Winter Season

In contrast to the winter of 2013-2014, the winter season of 2014-2015 began with cooler-than-normal temperatures in November, broken up by more moderate weather throughout the country during the mid-winter. Figure 1-4 illustrates the temperature pattern for the entire winter season, with most states in the Eastern United States experiencing temperatures that were below average.

***Figure 1-4 Statewide Average Temperature and Temperature Rank (Coldest to Warmest), October 2014 – March 2015***

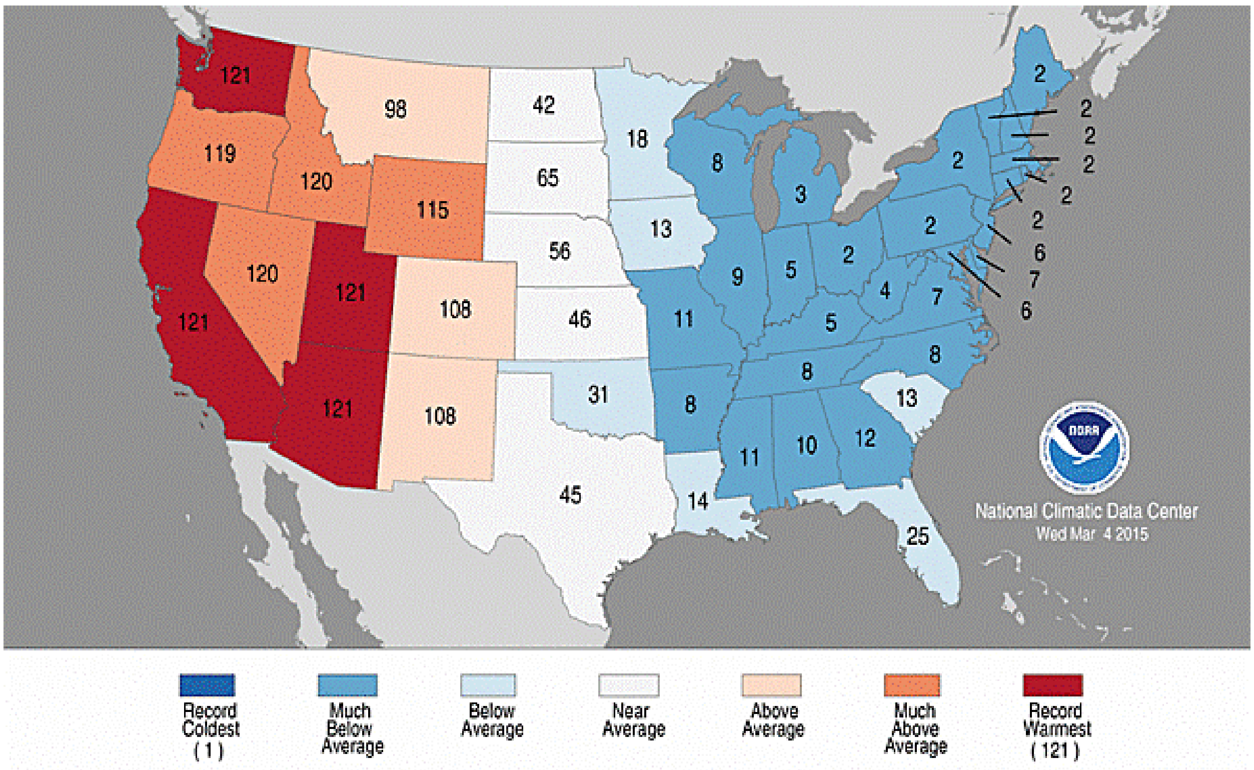



This map shows the average winter season temp slotted into bins of "Near Average," "Below Average," etc. The number is the rank of the winter seasons temperature in terms of coldest to warmest over the period 1895-2014. For example, the average temperature in Ohio during this season was Much Below Average and the 12th coldest winter over the 1895 to 2014 period.

Source: National Temperature and Precipitation Maps, National Centers for Environmental Information, National Oceanic and Atmospheric Administration (NOAA), Average Period: 1895-2014. Accessed August 1, 2015, http://www.ncdc.noaa.gov/temp-and-precip/us-maps/6/201503?products[]=statewideavgrank.

The season's most severe weather was experienced in February, in comparison to the prior year when the peak cold temperatures occurred in January. Figure 1-5 illustrates the average temperatures for February 2015 across the United States. Twenty-three states across the Northeast and into the South reported "top-10" coldest months in February 2015, with several cities setting records (e.g., Buffalo, Chicago). In addition, multiple storms brought unprecedented amounts of snow to the Northeast; Boston recorded 108.6 inches of snow for the season, making 2014-2015 the snowiest season on record.[7]

*Figure 1-5 Statewide Average Temperature and Temperature Rank (Coldest to Warmest), February 2015*




This map shows the average temperatures for February 2015 slotted into bins of "Near Average," "Below Average," etc. The number is the rank of the February temperatures in terms of coldest to warmest February over the period 1895-2014. For example, during February 2015 Virginia experienced weather that was Much Below Average and was the 7th coldest February over the 1895 to 2014 time period.

Source: National Temperature and Precipitation Maps, National Centers for Environmental Information, National Oceanic and Atmospheric Administration (NOAA), Average Period: 1895-2014. Accessed August 1, http://www.ncdc.noaa.gov/temp-and-precip/us-maps/1/201502?products[]=statewidetavgrank.

## Seasonal Heating Degree Days and Monthly Temperatures

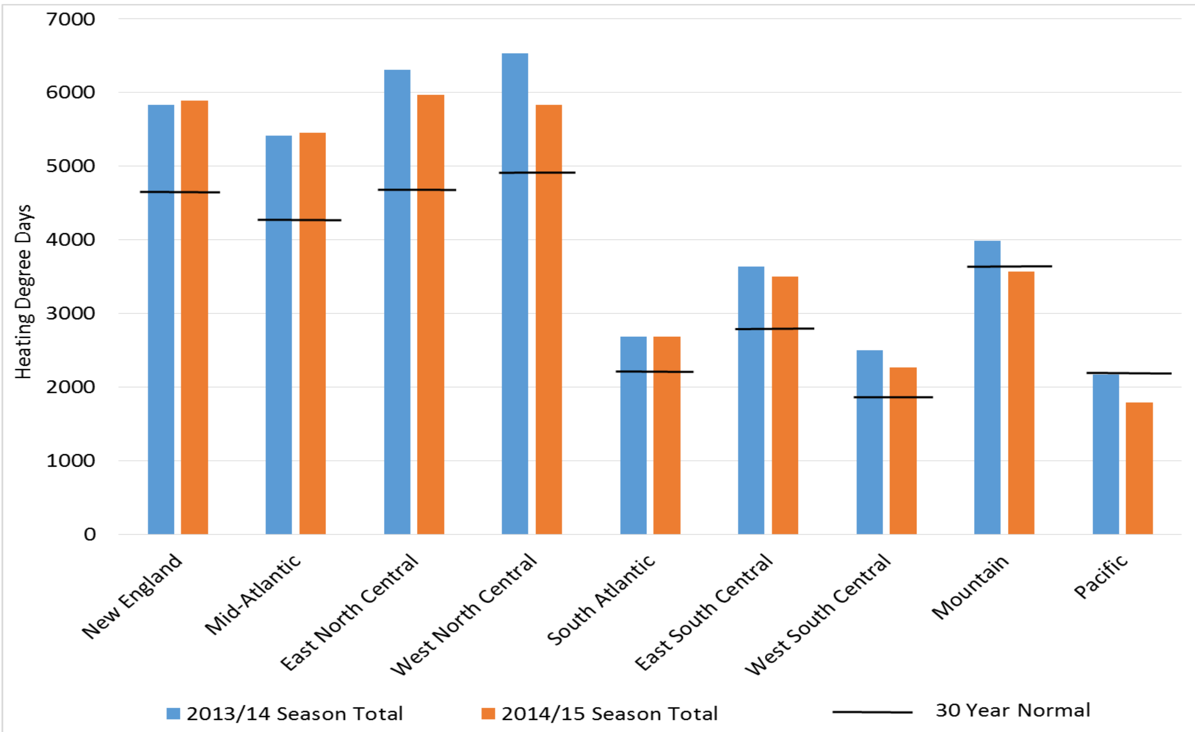
Looking across both winters and the implications for the fuels and electricity markets, it is useful to review the weather impacts in terms of heating degree days (HDD) — a measure of relative coldness or warmth during the winter season (see Glossary for full definition). Figure 1-6 shows the HDD for the two winters, by region, in comparison to a 30-year normal HDD.

As the figure shows, the Western part of the United States experienced temperatures that were warmer than normal and fewer HDDs than in the rest of the country and in relation to the historic regional average. The Central United States (including the West and East North

[7] NOAA National Climate Data Center, November 2014, retrieved on May 19, 2015 from http://www.ncdc.noaa.gov/sotc/national/201411.

Central and West and East South Central regions) all recorded higher heating degree days than normal in both 2013-2014 and in 2014-2015, although the 2014-2015 HDD figures deviated less drastically from the historical average in some regions.

***Figure 1-6 Heating Degree Days by Region and Normal for the 2013-2014 and 2014-2015 Winter Season as Compared to 30-Year Normal HDD***




Source: National Weather Service, Climate Prediction Center, National Oceana and Atmospheric Association (NOAA), Accessed August 1, 2015. http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/

In contrast, in New England and the Mid-Atlantic regions the 2014-2015 heating season was slightly colder than the previous heating season, the only regions that showed this trend. However, as mentioned above, the pattern of the 2013-2014 winter — characterized by long stretches of bitterly cold weather — stressed energy markets more than the intermittent cold snaps of 2014-2015. The South Atlantic region showed roughly average heating trends in both 2013-2014 and 2014-2015.

These total winter averages do not tell the entire story since both winters were punctuated by periods of bitter cold that stressed regional energy systems. Table 1-2 illustrates this phenomenon by examining the monthly deviations in HDD for each month and each region of focus for this report. The colors indicate the extent of the deviation in HDD from normal. As seen in the 2013-2014 winter, the higher levels of HDD persisted throughout the winter, especially in the Eastern and Central regions of the country. This trend contrasts with the pattern in 2014-2015 when extreme periods of cold were recorded in November and February (and to some extent in March in the East) but the cold spells were interrupted by warmer-than-normal temperatures during mid-winter.

*Table 1-2 Deviation in Monthly Heating Degree Days from Normal*

| Region | Oct | Nov | Dec | Jan | Feb | Mar | Season Average (Oct-Mar) |
|---|---|---|---|---|---|---|---|
| Winter 2013-2014 | | | | | | | |
| New England | -13% | 8% | 2% | 4% | 8% | 22% | 6% |
| Mid. Atlantic | -23% | 10% | -1% | 11% | 12% | 22% | 8% |
| E. N. Central | -6% | 9% | 7% | 14% | 24% | 25% | 14% |
| W. N. Central | 7% | 3% | 12% | 5% | 24% | 19% | 12% |
| So. Atlantic | -15% | 13% | -16% | 16% | -3% | 22% | 4% |
| E. S. Central | -11% | 20% | -3% | 20% | 10% | 20% | 11% |
| W. S. Central | 5% | 23% | 15% | 6% | 16% | 32% | 15% |
| Mountain | 4% | -13% | 4% | -12% | -7% | -14% | -7% |
| Pacific | -8% | -14% | -1% | -32% | -8% | -24% | -15% |
| Winter 2014-2015 | | | | | | | |
| New England | -23% | 7% | -13% | 6% | 32% | 20% | 7% |
| Mid. Atlantic | -25% | 11% | -11% | 7% | 32% | 19% | 8% |
| E. N. Central | -2% | 20% | -12% | 1% | 31% | 8% | 8% |
| W. N. Central | -6% | 19% | -13% | -10% | 21% | -8% | 0% |
| So. Atlantic | -26% | 30% | -15% | -2% | 31% | -4% | 4% |
| E. S. Central | -17% | 36% | -14% | -1% | 37% | -4% | 7% |
| W. S. Central | -40% | 34% | -18% | 4% | 23% | 6% | 5% |
| Mountain | -36% | -7% | -12% | -12% | -19% | -27% | -17% |
| Pacific | -56% | -22% | -17% | -25% | -35% | -46% | -30% |

Warmer than normal
< 10% colder than normal
≥ 10% colder than normal but < 20% colder than normal
≥ 20% colder than normal but < 30% colder than normal
≥ 30% colder than normal

Source: National Weather Service, Climate Prediction Center, National Oceanic and Atmospheric Administration (NOAA). Accessed August 1, 2015, http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/cdus/degree_days/

## Heating Fuels and Electricity Use by Region

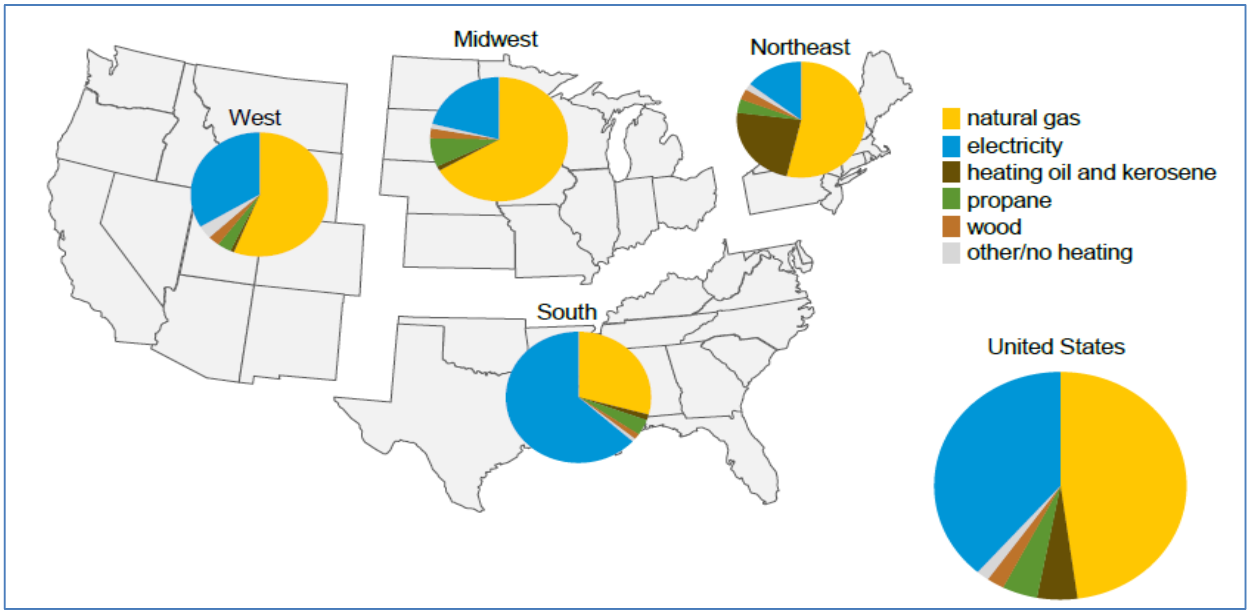
The heating fuel markets examined in this report include those for home heating oil, propane, and natural gas. Electric power markets are also examined as electricity is a dominant source of heat in the South, and has a small share in the Northeast and Midwest. Electricity is also the predominant choice for supplemental heating. Of the 30 percent of homes that have a supplemental heating source, approximately 60 percent have electric heating ability.[8] This figure is consistent across the country.

The use of heating fuels varies across the country, which is a function of dwelling age and type, and historical and current fuel access issues. Figure 1-7 illustrates the use of the heating fuels for space heating across the major regions of the country. Natural gas has the majority share of

[8] In the Northeast Census region, which includes most of the regions covered by these three ISO/RTOs, 52% of homes have natural gas as their heating fuel, based on 2009 survey data. Table HC6.7, Space Heating in U.S. Homes, by Census Region, 2009, Residential Energy Consumption Survey.

home heating in most of the country, with the highest market share in the Midwest and over 50 percent of the heating fuel market in the Northeast and West.

*Figure 1-7 Heating Fuel Market Shares across the United States*




Source: EIA Short Term Energy and Winter Fuels Outlook, October. 2014, based on analysis conducted by EIA using data from the U.S. Census Bureau, 2012 American Community Survey.

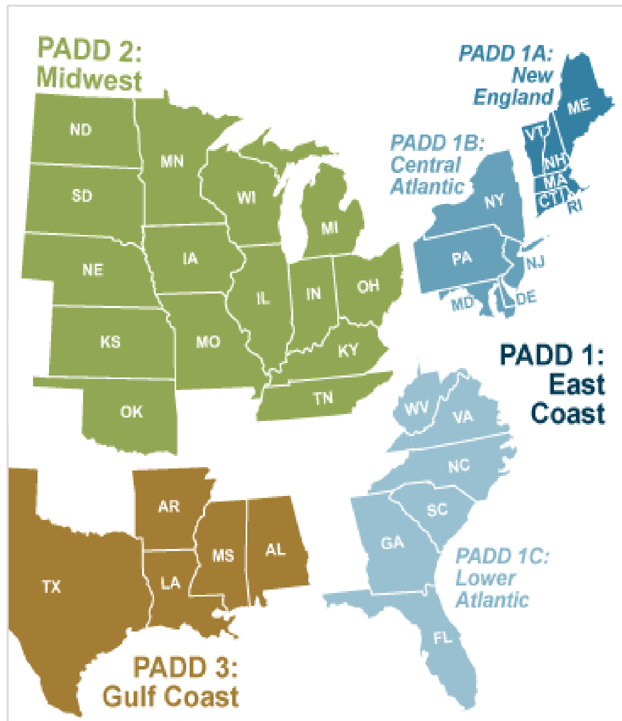
This report focuses on the events and market responses primarily in the Northeast and Midwest regions. The report does not focus on the West and South as these regions experienced weather that was generally warmer than normal and there were no significant fuel supply issues. In the Northeast, the problems of these two winters primarily related to high demand for heating oil and for natural gas. The power sector is also examined because of the considerable impacts the weather had on electric heating demand and also because natural gas is a major fuel for electricity generation in the Northeast. Pipeline deliverability constraints required generators to turn to heating oil and to a lesser extent power imports. The Midwest is examined primarily because of the problems encountered in the propane market. The remainder of the report examines these markets separately. Chapter 2 reviews the heating oil and distillate markets, Chapter 3 addresses the propane market, Chapter 4 discusses the natural gas market and, Chapter 5 analyzes the electric power market.

# 2. Heating Oil and Distillate Fuels Markets

## Summary

The near record cold temperatures during the winters of 2013-2014 and 2014-2015 led to constrained heating oil markets in the New England Petroleum Administration for Defense District (PADD 1A) and Central Atlantic Petroleum Administration for Defense District (PADD 1B)[9] regions, where heating oil is the primary fuel for space heating in 39% and 18% of homes, respectively.[10] In this section, PADDs 1A and 1B are collectively referred to as the "Northeast." These regions, and others, are identified in the Energy Information Administration (EIA) map shown in Figure 2-1.

*Figure 2-1 EIA PADDs 1 (A, B, & C), II, & III*




During both winters, heating oil markets endured the greatest stress in January and February as prolonged periods of low temperatures — 20–30 degrees below normal for weeks at a time — drove home-heating demand higher than normal. In addition, natural gas pipeline capacity constraints for gas supply to the electric power sector and high gas prices increased distillate demand for use as a substitute fuel at gas-fired power plants that have the ability to switch fuels.[11]

---

[9] The United States is divided into five Petroleum Administration for Defense Districts, or PADDs. These geographic aggregations were created during World War II under the Petroleum Administration for War to ration gasoline and other fuels derived from petroleum. Today, these regions are still used for data collection and analysis purposes. See *PADD regions enable regional analysis of petroleum product supply and movements, EIA, September 7, 2012. Accessed on August 1, 2015: http://www.eia.gov/todayinenergy/detail.cfm?id=4890.*

[10] Source: U.S. Census Bureau Information; EIA Information on residential fuel use, and ICF calculations.

[11] Heating oil is a type of distillate fuel that is closely related to diesel. Historically, the primary difference between the two fuels had been that heating oil was allowed to contain more sulfur than diesel fuel. However, as of 2012, New York State, the largest market for heating oil in the United States, began requiring that all heating oil used in the state contain less than 15 parts per million (ppm) sulfur, the same requirement as for on-road ultra-low sulfur diesel (ULSD). In 2014, Massachusetts, New Jersey, and Vermont began requiring that heating oil contain less than 500 ppm sulfur. As a result of these changes, there is no single distillate specification for heating oil and it is not possible to disaggregate supply, demand, and price data for heating oil from distillate used for other purposes, such as transportation, farm equipment, and power generation.

The market stress driven by the extreme cold was compounded due to very low stocks of distillate in the Northeast entering the winter in 2013 and 2014 compared to the prior five winters. These low stocks reduced the industry's buffer against unanticipated demand spikes or supply disruptions and contributed to price volatility in distillate markets.

The combination of weather-driven demand shocks and low inventories led to dramatic price increases in the Northeast, with spot distillate fuel oil prices trading more than 80 cents per gallon ($33.60 per barrel) above Brent crude oil for brief periods in both February 2014 and March 2015 — double the spreads seen at the beginning of each winter and significantly above previous winter peaks (See Pricing Section below). The sudden price spikes appeared to be driven by rapid demand increases from dual-fuel gas generators responding to either natural gas pipeline capacity constraints or to sharp regional gas price spikes, which drove economic fuel switching to relatively less expensive distillate fuel oil. The increase in spot distillate fuel prices rapidly cascaded to residential and commercial customers.

**Distillate Fuel Oil Products**

There are a number of different distillate fuel oil products in commercial and residential markets. They are all similar hydrocarbons refined from crude oil. Diesel fuel is a distillate fuel oil which is used in on- and off-road applications and must have sulfur levels under 15 parts per million. Heating oil is a distillate fuel oil which is very similar to diesel at the molecular level, but can have higher sulfur levels, especially in the Northeast where some states have higher sulfur limits.

The price benchmark for distillate fuels is the 15 ppm NYMEX ULSD (Ultra Low Sulfur Diesel) futures contract. Prices for heating oil at higher sulfur levels are often lower than ULSD, but in some states (New York), the heating oil specification for sulfur is the same as ULSD. This report examines ***total distillate fuel oil stocks*** in the Northeast and uses ULSD prices to examine trends and market events for distillate fuel oil use for heating oil purposes, on- and off-road use, and for power generation

In addition to demand and price impacts, the extreme cold in the Northeast in early 2015 caused operational problems at regional refineries and froze rivers and waterways, inhibiting the marine transport of heating oil to some marine-dependent markets, driving up prices further.

Despite these challenges and lower stocks entering winters 2013-2014 and 2014-2015, demand for heating oil in Northeast markets was met during both winters, as the U.S. Coast Guard worked diligently to keep critical marine routes open, and a combination of stock drawdowns and import cargoes made up for disruptions in refinery supply of heating oil.

Furthermore, heating oil prices in winter 2014-2015 fell substantially due to a sharp decline in global crude oil prices over the second half of 2014. This decline in prices fortuitously limited the overall price impacts on consumers of the spikes that did occur.

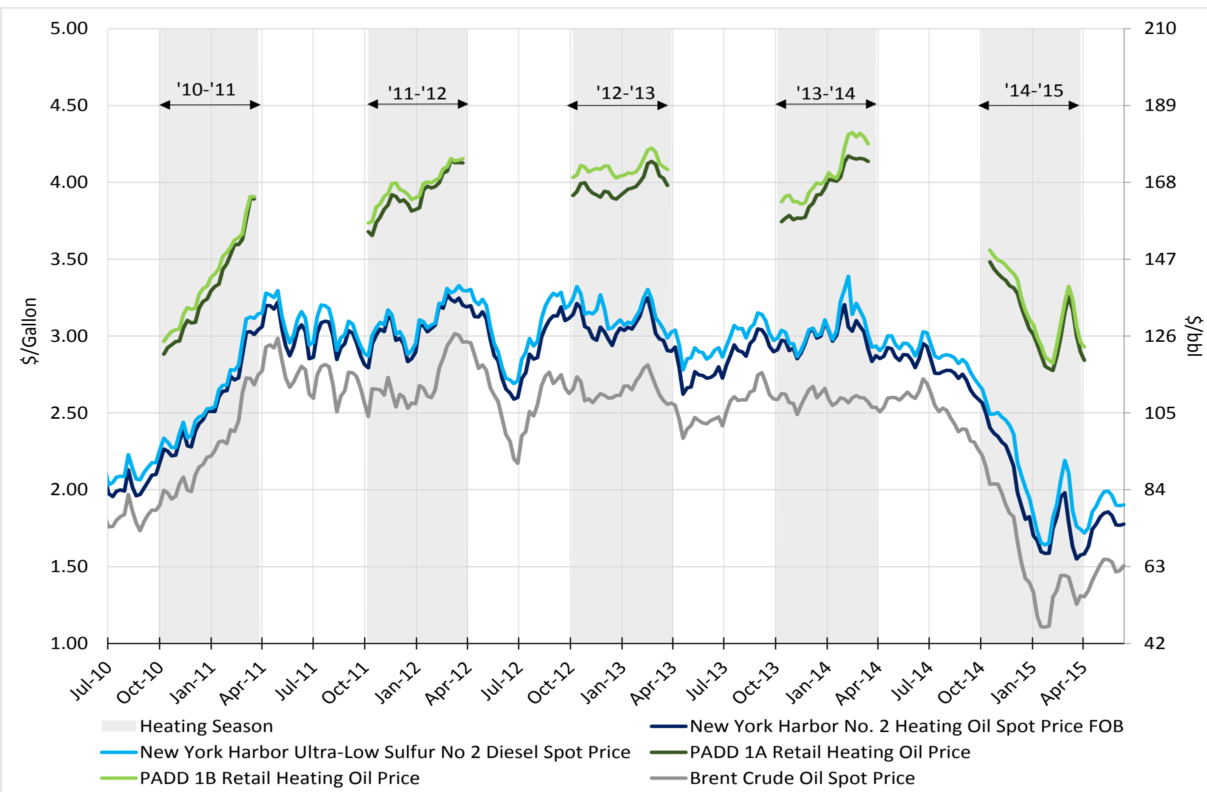
## Prices

Northeast heating oil prices experienced relative price spikes at all levels of transactions in both February 2014 and February 2015. Wholesale spot prices for high-sulfur heating oil and ultra-low-sulfur diesel (ULSD) in New York Harbor (NYH) are the primary market signals for wholesale and retail heating-oil prices in New England (PADD 1A) and the Central Atlantic

(PADD 1B). These product prices, in turn, closely follow the price of Brent crude oil, which is the price benchmark for feedstock used in Atlantic Basin refineries.

Figure 2-2 plots retail heating oil prices in both regions against spot heating oil and ULSD traded in NYH, and against Brent crude oil. As shown in Figure 2-2, retail prices tend to follow wholesale spot market prices, and in most cases react accordingly in response to shifts in spot markets. Consequently, disruptions in distillate supply from refinery outages or delayed shipments, as well as sudden changes in distillate demand due to prolonged cold snaps or gas-fired power plant fuel switching, can have significant impacts on retail prices for homeowners and businesses. Retail heating oil prices were the highest in January and February 2014, amid \$100+ per barrel crude oil prices and severely cold temperatures, with the high at \$4.17/gallon in New England (PADD 1A) and \$4.33 in Central Atlantic (PADD 1B) in February 2014, respectively. Heating oil prices in winter 2014-2015 were well below prices in the previous three winters due to a sharp decline in global crude oil prices over the second half of 2014, although a spike in the crude price in February 2015 contributed to a sharp increase in retail heating oil prices.

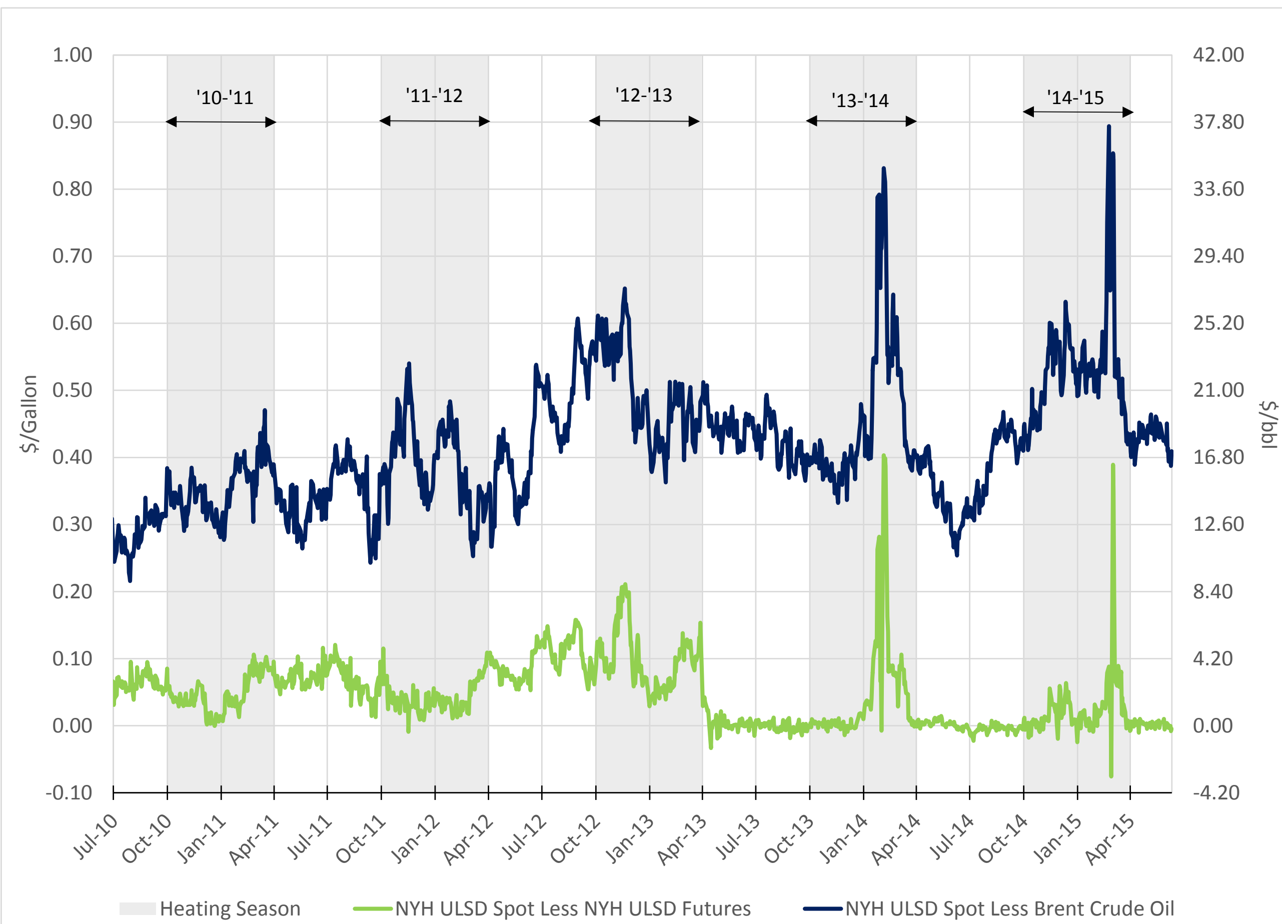
***Figure 2-2 Weekly New England (PADD 1A) and Central Atlantic (PADD 1B) Retail Heating Oil Prices vs. New York Harbor Spot No. 2 Distillate and Brent Crude Oil Prices: July 2010 – April 2015***




Source: Energy Information Administration, *Weekly Heating Oil and Propane Prices*. The following Sub-PADD data are contained in this chart: 1A and 1B. New York Harbor is a major price hub within Sub-PADD 1B. Link: http://www.eia.gov/dnav/pet/pet_pri_wfr_dcus_nus_w.htm.

In order to isolate movements in the heating oil prices attributed to weather from macro movements in global crude prices, it is necessary to observe the spread between the price of finished heating oil and the price of the underlying crude commodity. Figure 2-3 plots the daily spread between NYH ULSD and Brent crude oil. This spread widens during high heating oil demand periods and supply disruptions. Figure 2-3 shows that this spread briefly spiked sharply to as high as 80 cents per gallon ($33.60 per barrel) in late January and early February 2014, and almost 90 cents per gallon ($37.80 per barrel) in early March 2015. Another key measure of temporary supply tightness is the spread between spot NYH ULSD (fuel for prompt delivery) and NYMEX ULSD front month futures (fuel for delivery at the same location in the next month). A spike in this intertemporal spread is indicative of parties needing to secure volumes promptly to meet supply obligations. Figure 2-3 shows the price spread between NYH ULSD and NYMEX ULSD front-month futures. In late January and early February of 2014 and early March of 2015 this spread spiked to approximately 40 cents per gallon ($16.80 per barrel), up from essentially zero under normal circumstances.

***Figure 2-3 Daily New York Harbor ULSD Spot Price Spreads vs. ULSD Futures and Brent Crude Oil Spot Prices: July 2010 – April 2015***

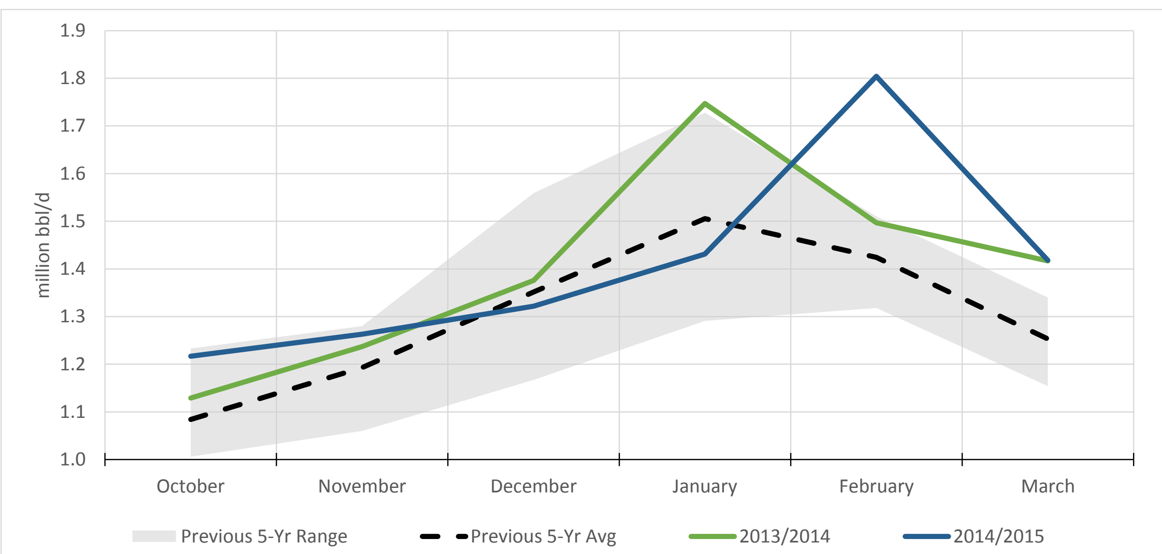



Source: Reuters EIKON. This chart contains spot and futures price data from New York Harbor, a major pricing hub within Sub-PADD 1B. Note: prior to April 1, 2013, the NYMEX futures contract was based on No. 2 fuel oil, a higher -sulfur and lower-valued commodity than ULSD.

## Demand

The relative price spikes experienced in winters 2013-2014 and 2014-2015 were largely driven by extreme cold weather, which raised demand for heating oil for residential and commercial space heating and triggered very high short-term demand for distillate fuel oil as a substitute for natural gas in dual-fuel generators. The fuel switching by dual-fuel generators may have been driven by economics, due to sharp and extended spikes in Northeast gas prices caused by the cold, or by lack of available natural gas pipeline capacity for generators with interruptible supply contracts. For this analysis, the Energy Information Administration's "product supplied" data are used as a proxy for demand.[12] Figure 2-4 shows product supplied of distillate fuel oil on the East Coast (PADD1) in winters 2013-2014 and 2014-2015, compared with the average and with the range for the previous five winters. This chart shows product supplied of distillate fuel oil on the East Coast, which includes the Northeast, but also includes demand in the Southeast, where distillate fuel oil is rarely used for home heating. Product supplied data by sub region are (specifically for the New England or Central Atlantic regions) are not available. The product supplied figures shown in Figure 2-4 include distillate fuel oil used for home heating as well as for other purposes, such as on-road highway use, farm equipment, and electric power generation. Driven by demand for heating oil in the Northeast, overall East Coast distillate fuel oil demand typically peaks during the coldest winter months of January and February. During the average winter of the previous five years, distillate fuel oil demand peaked at 1.5 million bbl/d, although demand reached a high of 1.7 million bbl/d in January 2009. In the winters of 2013-2014 and 2014-2015 peak demand exceeded previous highs at 1.75 million bbl/d in January 2014 and 1.8 million bbl/d in February 2015, respectively.

***Figure 2-4 Monthly East Coast (PADD I) Distillate Fuel Oil Product Supplied in Winters 2013-2014 and 2014-2015 Compared to Prior 5-year Average and Range in Winters 2008-2009 to 2012-2013***




Source: Energy Information Administration, *Products Supplied*, EIA Survey Forms: 810, 811, 812, 813, 814, 816, and 817. Link: http://www.eia.gov/dnav/pet/pet_cons_psup_dc_r10_mbbl_m.htm.

[12] Product supplied is an approximation of consumption of petroleum products. It measures the disappearance of these products from primary sources, i.e., refineries, natural gas processing plants, blending plants, pipelines, and bulk terminals.

## Distillate Fuel for Power Generation

During both winters, distillate fuel oil use for electricity generation contributed to peak demand as dual-fuel generators that normally burn natural gas switched fuels in response to natural gas pipeline capacity constraints (which precluded some interruptible contract holders from accessing space on the pipeline) and sharp gas price spikes, and—to a much lesser extent—as some small distillate fuel oil-fired-only peaking power plants were brought online.

In recent years, there has been a steady increase in the development of new gas-fired electric generating capacity in the Northeast in response to the economics of these plants vis-à-vis alternatives, as well as in response to existing and expected future air emissions regulations. Much of this new gas-fired capacity is dual-fuel, meaning it has the capability to burn petroleum distillates as an alternate fuel source. Because most gas-fired power plants acquire gas through non-firm contracts, their supply is subject to interruption. Operators of these plants must weigh the value of investing in No. 2 fuel oil and/or diesel capability and the necessary storage as a substitute generation fuel when gas is not available. In addition, extreme spikes in regional natural gas prices can make it economically advantageous for some dual-fuel generators to burn distillate fuel oil rather than natural gas even when pipeline gas is available (See Electricity chapter for further discussion on fuel switching).

Figure 2-5 shows distillate fuel oil demand for electricity generation in the New England (PADD 1A) and Central Atlantic (PADD 1B) regions. The figure shows that combined distillate fuel oil demand in these two regions reached approximately 68,000 bbl/d in both January 2014 and February 2015, up from a previous high of approximately 16,000 bbl/d in July 2010 (a summer peak). In January 2014 and February 2015, distillate fuel use at power plants in the New England and Central Atlantic regions made up an estimated 3-4% of total

### Winter Reliability Programs: ISO-New England

In winter 2013-2014 and 2014-2015, ISO New England's (ISO-NE's) winter reliability program incentivized dual-fuel generators to build oil stocks at their facilities. The 2013-2014 program provided payments to participating generators to establish an initial block of fuel inventories in their tanks as of December 1, and in the case of some dual-fuel generators, to replenish their fuel inventory until the end of the program (February 28).[a] ISO-NE reported that the 2013-2014 program awarded approximately 3.1 million barrels of initial inventories at the beginning the program season and approximately 500,000 barrels of replenishment fuel oil throughout the program's duration.[b]

In winter 2014-2015, ISO-NE replaced the oil inventory program with an unused oil inventory program. Instead of paying generators for upfront inventory, the 2014-2015 program compensated participating generators for unused fuel inventories at the end of the winter, thus reducing the risk of over estimating the amount of fuel needed at the start of the winter.[c]

Despite these incentives, the ability of dual-fuel plants to build oil inventories is limited by available onsite storage capacity. As noted earlier, dual-fuel generators typically only maintain a few days of onsite storage. After those supplies are exhausted the generators turn to the spot market to replenish supplies.

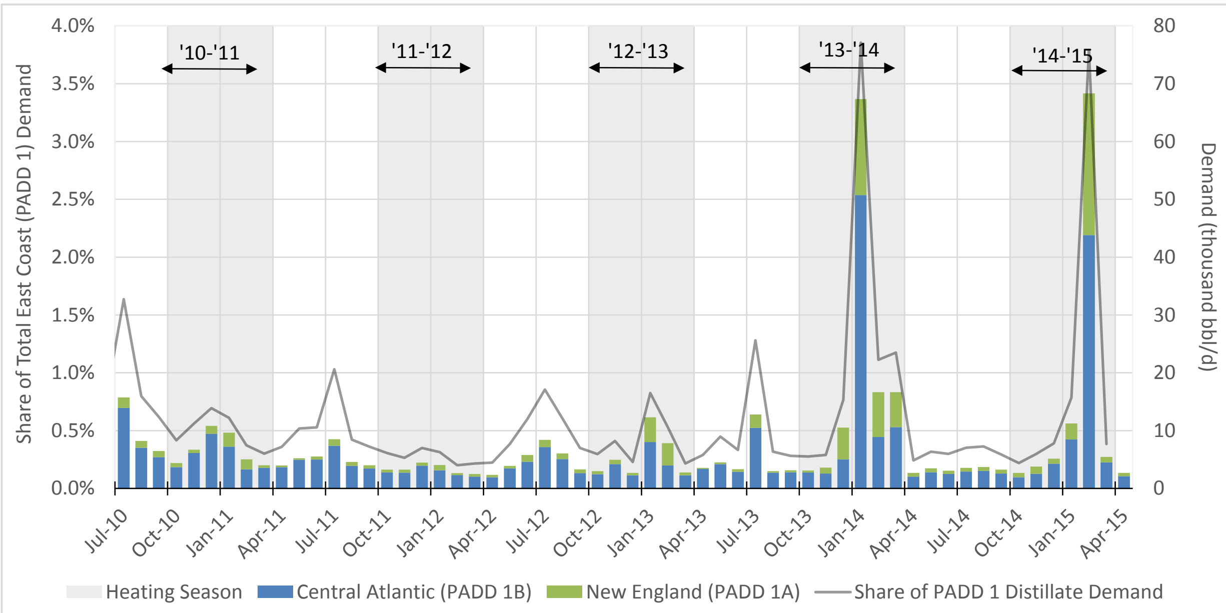
a) 144 FERC 61,204. Issued September 16, 2013. http://www.iso-ne.com/regulatory/ferc/orders/2013/sep/er13-1851-000_9-16-2013_winter_rel.pdf. July 30, 2015.

b) "Winter Operations Related Improvements: Overview of Market-Based Solutions and Reliability Programs to Address Identified Risks with Winter Operations." ISO New England. Presentation. Gas Electric Senior Task Force Meeting. May 23, 2014. http://www.pjm.com/~/media/committees-groups/task-forces/gestf/20140521/20140521-item-07a-overview-of-the-winter-reliability-program.ashx

c) "ISO New England Inc., Docket No. ER14-000, Winter 2014-15 Reliability Program (Part 1 of 2)." ISO New England. July 11, 2014. http://www.iso-ne.com/regulatory/ferc/filings/2014/jul/er14-2407-000_win_rel_pro_7-11-2014.pdf. July 30, 2015.

distillate fuel oil demand in the East Coast region, up from a typical winter heating season average of less than 0.5% and a previous 3-year high of 1.6% in July 2010.[13]

***Figure 2-5 Distillate Fuel Oil Demand for Electricity Generation in the New England and Central Atlantic Regions and Share of Total East Coast Demand: July 2010 – April 2015***




Source: Energy Information Administration, *Consumption of Fuels Used to Generate Electricity,* EIA Survey Form 923. Link: http://www.eia.gov/electricity/data.cfm#consumption.

Sudden increases in demand for distillate fuel oil for power generation during the winter months can contribute to large price spikes because they bring new buyers into the market at a time when supply is already tight. Power plants that use distillate fuel oil as a back-up fuel typically maintain only a small inventory of fuel onsite in order to avoid the expense of purchasing fuel that they may not use. [14] As a result, most of these plants can run for only a short time before onsite stocks are depleted and new supply must be obtained. For example, Dominion's 450-megawatt Manchester Street power station in Providence, Rhode Island, stores distillate at a 22,000-bbl onsite tank, enough to fuel the plant for approximately three days.[15] The sustained cold weather, high gas prices, and gas pipeline constraints in January 2014 and February 2015 may have driven many generators into the spot market to replenish distillate fuel, contributing to several large spikes in spot prices.

It should be noted that the peak demand of 68,000 b/d for distillate for power generation in January 2013 and February 2014 were monthly averages. The actual spot-in-time demand may have been two to three times higher for periods within the month when pipeline gas supply was interrupted or when high gas prices made burning distillate economical. This sudden entrance

---

[13] Shares calculated by dividing monthly distillate fuel oil demand for power generation in Figure 2-5 by monthly distillate fuel oil product supplied in Figure 2-4.

[14] http://www.iso-ne.com/aboutiso/fin/annl_reports/2000/2014_reo.pdf.

[15] http://energy.gov/sites/prod/files/2014/04/f15/Remarksof_KevinR.Hennessy_Dominion_April21.pdf.

of dual-fuel generators in the distillate spot market may explain the sharp, short-lived spikes in the ULSD spot vs. NYMEX price spread shown in Figure 2-3.[16] This demand surge by dual-fuel generators typically occurs during periods of extreme cold, when supply chains are already stretched to meet residential and commercial demand peaks, and are being challenged by the physical difficulty of loading and transporting barges in extreme conditions.

## Supply

Despite demand spikes for home heating and electricity generation, distillate fuel oil suppliers were able to keep markets supplied during both winters, although refinery outages and transportation problems caused by the near record cold posed significant challenges in January and February 2015 (see Case Study box at the end of the chapter). Figure 2-6 compares sources of supply to the East Coast (PADD 1), including in-region refinery production, net movements from other regions (primarily pipeline shipments on Colonial and Plantation pipelines and marine deliveries to Florida), net imports from other countries (primarily Canada with swing supply from Russia), and net stock withdrawals from in-region stocks. Figure 2-6 indicates that East Coast refineries and net movements from other regions typically supply around 1.0 to 1.2 million bbl/d each month, and higher volumes do not necessarily coincide with the peak demand winter months.[17]

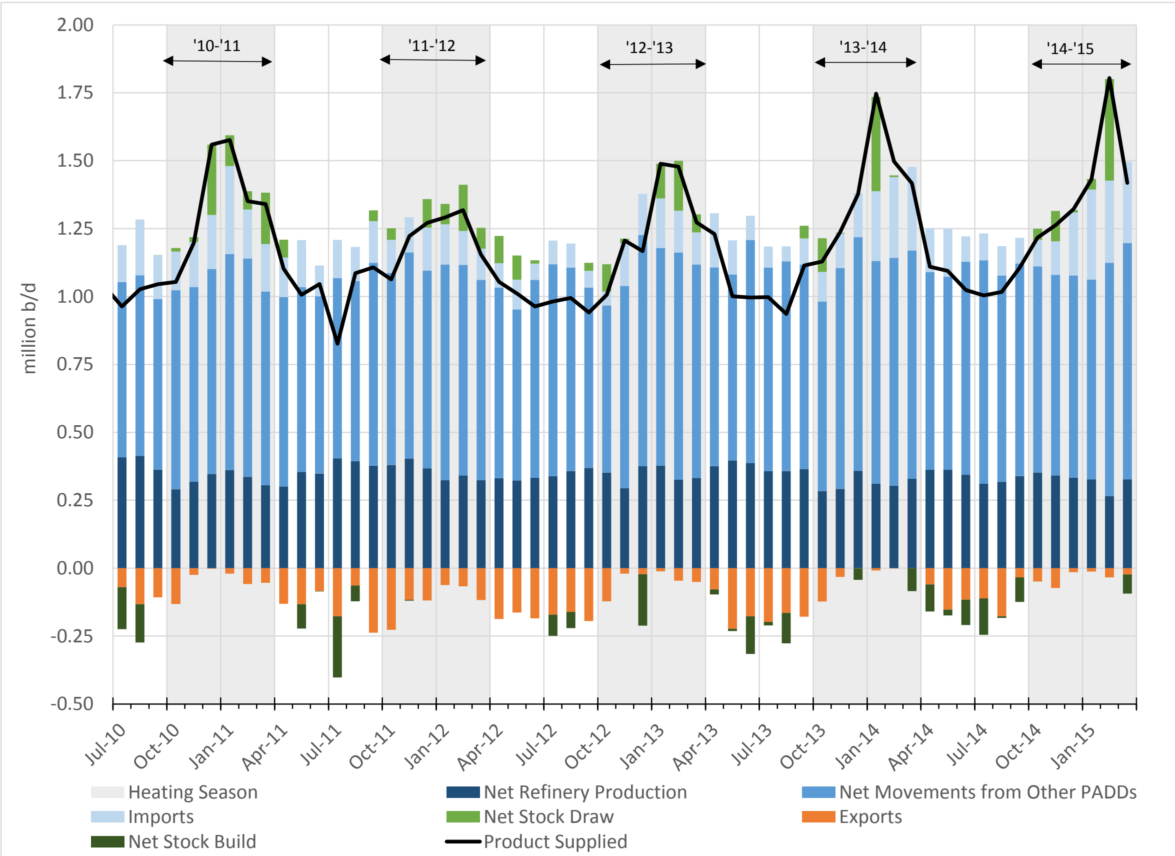
East Coast refineries — like refineries elsewhere—have limited flexibility to increase distillate production, and the Colonial Pipeline — the primary product line supplying the Northeast—typically runs at full capacity and does not have the space to increase distillate volumes to meet unexpected spikes in demand. Swing supply — the additional volume needed to meet peak demand during the winter months — is primarily supplied via imports from Canada and the Atlantic Basin, and from stock drawdowns at regional bulk storage facilities. In the peak demand months of January 2014 and February 2015, imports and stock drawdowns added approximately 0.6 to 0.7 million bbl/d of swing supply to the East Coast.

---

[16] The spot price reflects the premium or discount a buyer is willing to pay to receive prompt supply (within the next week) versus the NYMEX futures price.

[17] Energy Information Administration, *Net Refinery Production, Products Supplied, Net Movements by Pipeline, Tanker and Barge, Imports by Processing Area, and Exports.* EIA Survey Forms: 810, 811, 812, 813, 814, 816, and 817. Accessed on July 23, 2015: http://www.eia.gov/dnav/pet/pet_pnp_refp2_dc_r10_mbbl_m.htm, http://www.eia.gov/dnav/pet/pet_cons_psup_dc_r10_mbbl_m.htm, http://www.eia.gov/dnav/pet/pet_move_netr_d_r10-z0p_VNR_mbbl_m.htm, http://www.eia.gov/dnav/pet/pet_move_imp2_dc_R10-Z00_mbbl_m.htm, http://www.eia.gov/dnav/pet/pet_move_exp_dc_R10-Z00_mbbl_m.htm.

*Figure 2-6 Distillate Fuel Oil Product Supplied and Sources of Supply to the East Coast (PADD 1): July 2010 – March 2015*



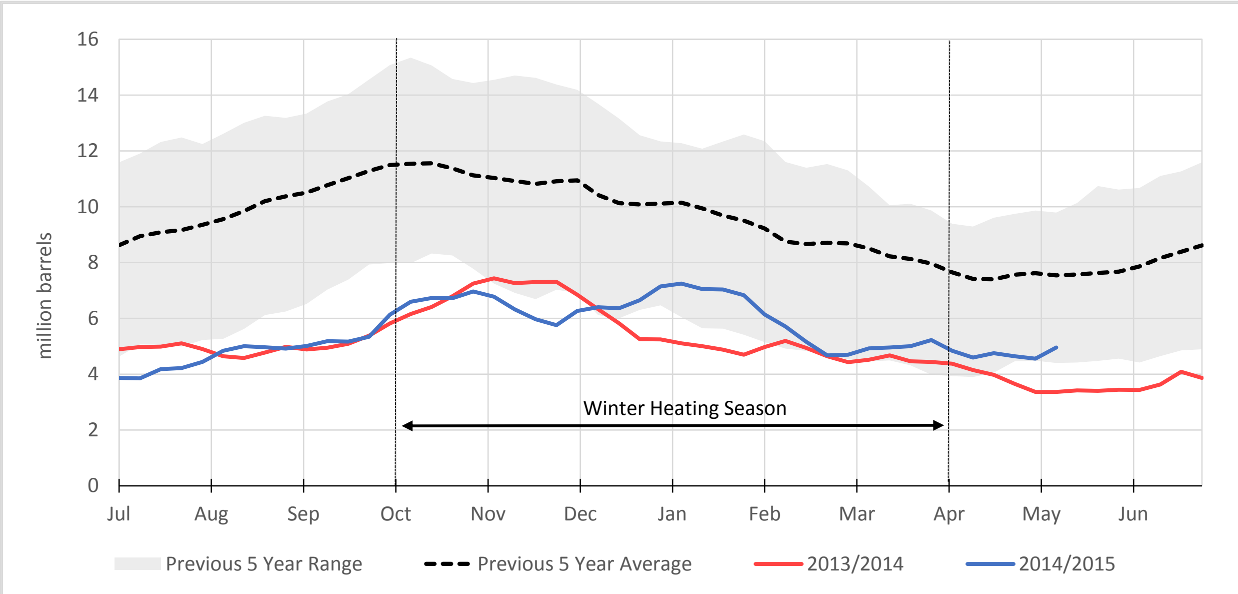

Source: Energy Information Administration, *Net Refinery Production, Products Supplied, Net Movements by Pipeline, Tanker and Barge, Imports by Processing Area, and Exports.* EIA Survey Forms: 810, 811, 812, 813, 814, 816, and 817. Link: http://www.eia.gov/survey.

## Stock Drawdowns

Drawdowns from inventories were an important component of swing supply to meet peak heating oil demand in the Northeast in winters 2013-2014 and 2014-2015. Distillate fuel oil inventory levels in both PADDs 1A and 1B entered both winter heating seasons near or below the early October low of the prior five-winter period (from winter 2008-2009 to winter 2012-2013) and the near record cold temperatures and refinery disruptions led to larger-than-average inventory drawdowns during both winters (2013-2014 and 2014-2015). Figures 2-7 and 2-8 present inventories at primary storage facilities, including refineries and pipeline facilities, and at bulk terminals, but do not include volumes stored at secondary terminals and volumes stored on-site at end users' premises, such as power plants. [18]

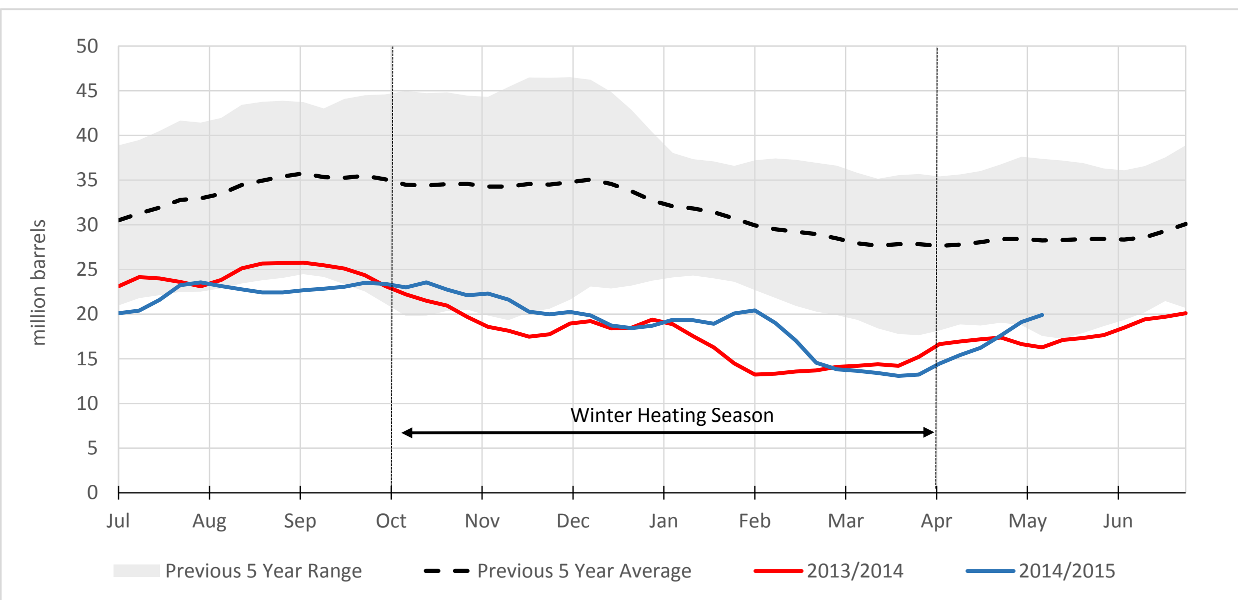
[18] A bulk terminal is primarily used for storage, marketing, and often blending of petroleum products and has total bulk shell storage capacity of 50,000 barrels or more, and/or receives petroleum products by tanker, barge, or pipeline (U.S. Energy Information Administration, Instruction for Form EIA-815).

*Figure 2-7 New England (PADD 1A) Distillate Fuel Oil Inventories, 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013.*




Source: Energy Information Administration, *Total Stocks*, EIA Survey Forms 800, 801, 802, 803, 809. Link: http://www.eia.gov/dnav/pet/pet_stoc_wstk_dcu_r1x_w.htm.

*Figure 2-8 Central Atlantic (PADD 1B) Distillate Fuel Oil Inventories, 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013.*




Source: Energy Information Administration, *Total Stocks*, EIA Survey Forms 800, 801, 802, 803, 809. Link: http://www.eia.gov/dnav/pet/pet_stoc_wstk_dcu_r1y_w.htm.

Both the 2013-2014 and 2014-2015 winters saw sharper-than-normal net drawdowns of distillate fuel inventories, particularly in the peak demand months of January and February. Over the previous five winters, the average drawdown from the beginning of January through the end of February was approximately 5.6 million barrels, or approximately 100,000 bbl/d, in the New England and Central Atlantic regions. Over these same two months in 2014, the drawdown in these regions averaged 123,000 bbl/d, while in 2015 it averaged 145,000 bbl/d. Despite the low inventories and sharp drawdowns during both winters, inventories met demand.[19]

Since 2008, overall distillate fuel oil stocks in both New England (PADD 1A) and Central Atlantic (PADD 1B) regions have fallen significantly from the levels represented in the upper bounds of the prior 5-year ranges. From 2008 through 2011, total Northeast (PADDs 1A and 1B combined) stocks at the beginning of the heating season ranged between 40 million and 60 million barrels. Since 2012, by contrast, Northeast stocks have begun the heating season at, or just below, 30 million barrels.[20]

Several factors may explain the lower Northeast distillate inventories entering the winters of 2012-2013, 2013-2014 and 2014-2015. First, in 2012, New York State—the largest demand market for heating oil in the United States — changed its heating oil sulfur requirement to 15 parts per million, identical to the requirement for on-road ULSD. This provided the industry greater flexibility to consolidate storage capacity for ULSD and heating oil at bulk terminals in Northern New Jersey and throughout New York, allowing them to reduce overall distillate stocks. Second, strong domestic refinery margins, due to relatively cheap Bakken and Eagle Ford shale oils flooding domestic refining markets, and unfavorable storage economics, due to the weakening of the normal summer contango[21] in the futures market, incentivized East Coast (PADD 1) refiners to export distillate fuels during "non-winter" months (April through September) rather than building inventories in advance of the heating season. The trend in distillate exports has escalated since 2011 when the United States became a net exporter of petroleum products for the first time. Finally, on the demand side, the Northeast heating oil market has contracted as homeowners have converted oil-fired heating units to natural gas furnaces. Heating oil's share of residential heating demand has dropped from more than 35 percent of households in 2005 to less than 25 percent in 2013.[22] Lower stock levels make it more difficult for the industry to manage unexpected demand spikes and supply disruptions, with an associated increase in price volatility.

---

[19] Northeast Home Heating Oil Reserve - Guidelines For Release: http://energy.gov/fe/services/petroleum-reserves/heating-oil-reserve/northeast-home-heating-oil-reserve-guidelines.

[20] Calculated from data in Figure 2-7 and 2-8.

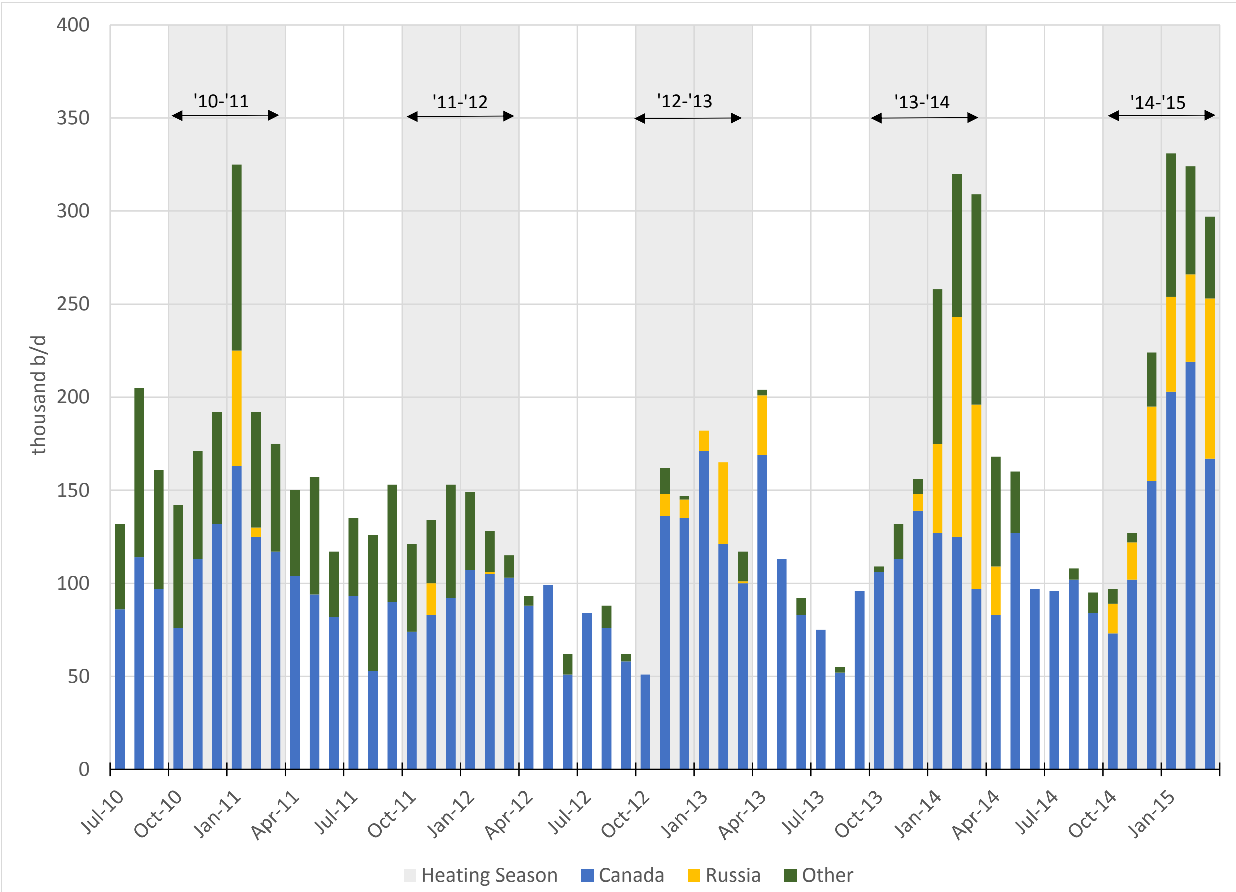
[21] Contango refers to a situation in which the futures price for a commodity is higher than the spot market price, due in part to consumers' preference for having access to the commodity in the future as opposed to purchasing the commodity now and storing it for future use. In a contango market, industry is not incentivized to build stocks.

[22] See http://www.eia.gov/todayinenergy/detail.cfm?id=18131.

## Imports

Imports were the other major source of swing heating oil supply into the Northeast in winters 2013-2014 and 2014-2015. Figure 2-9 plots U.S. East Coast (PADD 1) imports of distillate fuel oil by country of origin from July 2010 through March 2015. Overall, total imports to the East Coast exceeded 300,000 bbl/d during the peak demand months (January and February) of winters 2013-2014 and 2014-2015.

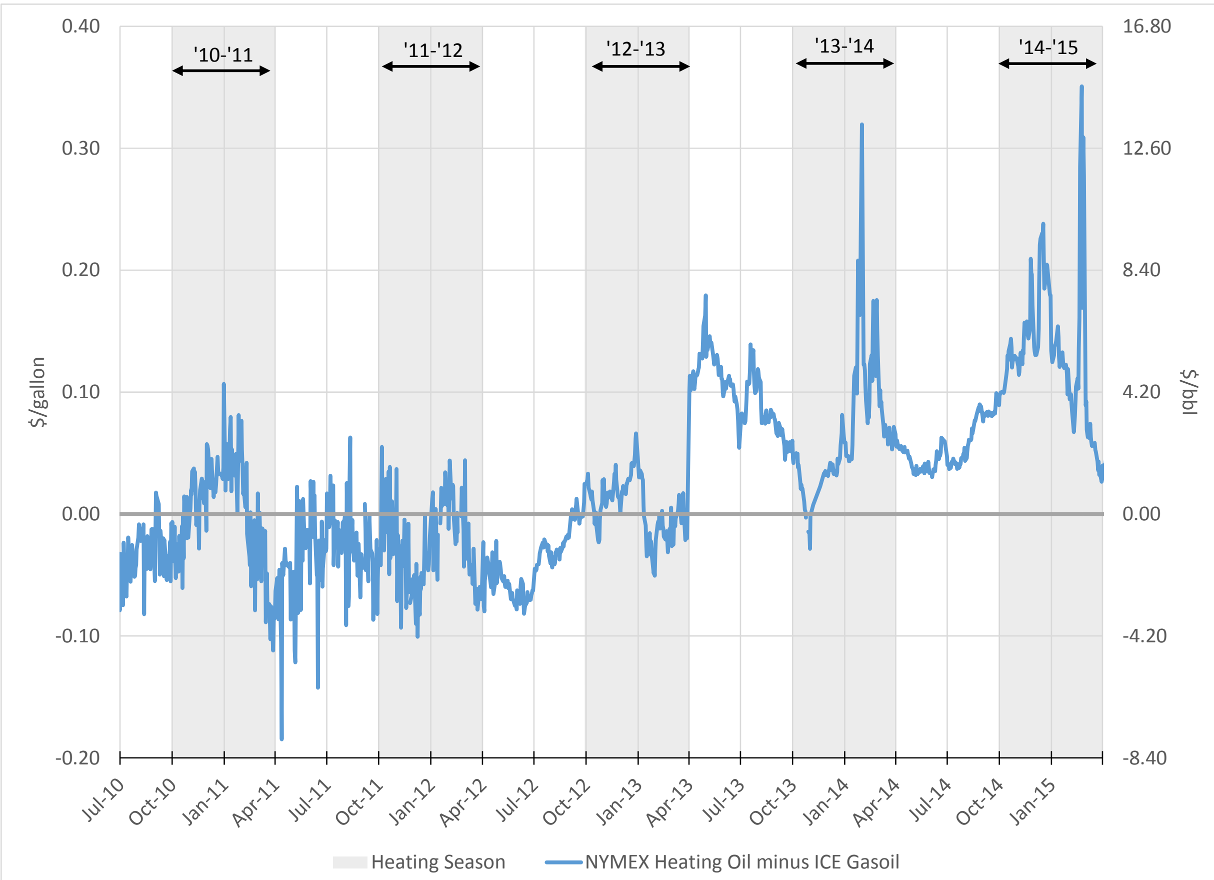
*Figure 2-9 East Coast (PADD 1) Imports of Distillate Fuel Oil by Country: July 2010 – March 2015*




Source: Energy Information Administration, *Imports by Processing Area*, EIA Survey Form 814. Link: http://www.eia.gov/dnav/pet/pet_move_imp2_dc_R10-Z00_mbbl_m.htm.

Year-round, Canada is the primary source of imports, with cargoes from eastern Canadian refineries shipped by tanker and barge to coastal New England, and, to a lesser extent, volumes trucked across the border to upstate New York and inland New England markets. Canadian volumes typically ramp up during the winter months, with peak-month volumes often exceeding 150,000 bbl/d. Non-Canadian distillate imports dropped to minimal levels in winters 2011-2012 and 2012-2013 as warmer-than-normal winter weather tempered demand, but rebounded significantly in winters 2013-2014 and 2014-2015 as high prices attracted cargoes to the Northeast from the Atlantic Basin. Figure 2-10 plots a key price spread that influences the direction of heating oil trade in the Atlantic Basin: the spread between the NYMEX front month heating oil futures price and the Intercontinental Exchange (ICE) gasoil front month futures price. When this spread widens beyond the cost of chartering a tanker across the Atlantic Ocean, it becomes economical for European producers to export heating oil to the U.S. Northeast[23] As shown in the figure, Russia was a major source of non-Canadian imports during both winters due to a strong trans-Atlantic arbitrage.

***Figure 2-10 NYMEX Heating Oil Front Month Futures Price Spread Over Intercontinental Exchange (ICE) Gasoil Front Month Futures Price: July 2010 – March 2015***




Source: Reuters EIKON. This chart compares the futures price for distillate fuel oil for delivery to New York Harbor (NYMEX Heating Oil) against the futures price for distillate fuel oil for delivery to the Amsterdam-Rotterdam-Antwerp area in Northwest Europe (ICE gasoil). Additionally, it shows that Russia was a major source of non-Canadian imports during both winters due to a strong trans-Atlantic arbitrage, which encouraged European and other international distillate producers to export heating oil to the U.S. Northeast.

23 An arbitrage is considered strong when the price differential is sufficient to more than cover the cost of transporting the fuel from the origin (in this case northwest Europe) to the destination (in this case New York Harbor).

## Severe Cold Affects Northeast Heating Oil Supply and Distribution


Photo credit: U.S. Coast Guard

Starting in early January 2015 and continuing through early March 2015, the Northeast region experienced an extended period of bitter cold temperatures that disrupted operations at refineries and resulted in the freezing of waterways that are used for marine transportation of heating oil. During this period, 51 out of 60 days were colder than normal, with temperatures reaching as low as 20 to 30 degrees below normal for weeks at a time. Although the refinery problems were severe, the impact on consumers was mitigated by stock drawdowns, seasonal increased imports (primarily from Canada, Russia, India, Brazil, and Saudi Arabia), and a steady delivery of heating fuels on major pipeline systems such as Colonial and Buckeye. In addition to temperature-related disruptions, record snow accumulations in parts of New England, including more than 108 inches in Boston for the season, inhibited transportation of heating oil on railways and roadways and blocked access to customer storage tanks. Some of the specific challenges included:

- Cold-weather-related shutdowns and operational issues at East Coast refineries resulted in a 24.9 percent decline in East Coast refinery utilization from the end of January to the end of February.[a] The restart of units at several refineries were delayed following maintenance outages, as the units struggled to get equipment restarted and pipes in the refineries needed to be sufficiently warm to resume operations. One refinery was also temporarily shut down when the freezing of the Delaware River cut off the plant's source of cooling water.[b] In addition, severe weather and deep snow levels resulted in delays in rail deliveries of crude oil to Northeast refineries, which rely on rail for roughly half of their crude oil input.[c]
- In addition to refinery curtailments, the extreme cold caused unprecedented thick ice and freezing in Northeast ports and waterways. Marine deliveries were delayed to terminals along the Hudson River in New York; along bays, creeks, and channels around Long Island; and along the Weymouth Fore River south of Boston Harbor in Massachusetts. Terminals that were affected reported low or empty stocks as a result of the delays.[d] The U.S. Coast Guard worked diligently to remove ice and keep critical ports and waterways open, however; several operators hired ice-breaking tugs to remove buildup around receipt docks to provide access for delivery vessels. Affected suppliers also entered into exchange agreements with other suppliers to allow competitors' trucks to load at terminals that were accessible.
- Snow-covered roads and driveways, along with heavy snow buildup, blocked access to residential tanks, affecting retail trucking distribution of heating oil to end-use customers. In response, fuel distributors increased shoveling personnel to clear truck delivery points, and several managers drove night shifts to rest other drivers. Priority deliveries were made to some customers with depleted fuel supplies.

a. http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=PET&s=W_NA_YUP_R10_PER&f=W

b. http://www.reuters.com/article/2015/02/20/refinery-operations-monroe-idUSL1N0VU0YX20150220

c. http://www.csx.com/share/wwwcsx_mura/assets/File/Customers/Service%20Overview/Service%20Update_022315.pdf, http://www.eia.gov/todayinenergy/detail.cfm?id=21092

d. http://www.bostonglobe.com/metro/2015/02/19/vast-stretches-boston-harbor-frozen/2SdwfgmxX2TKcc4NfpOZLI/story.html, http://www.dailymail.co.uk/news/article-2966974/Manhattan-encased-ice-deep-freeze-intense-Polar-Vortex-Hudson-turned-river-ice-record-lows.html, http://coastguardnews.com/coast-guard-cutter-line-ensures-delivery-of-vital-home-heating-oil-to-port-jefferson/2015/03/02/

# 3. Propane Markets

## Summary

Propane is widely used throughout the United States for a variety of purposes, including space heating, water heating, cooking, and grain drying.[24] Propane is particularly important as a residential space heating fuel in the Midwest, where 7.8% of single-family homes rely on propane, and in the Northeast, where propane is used to heat 3.9% of single-family homes. Both regions were significantly affected by high prices and shortages in propane supply during the winter of 2013-2014.[25]

**Effects of the Winter of 2013-2014 Propane Shortage on Consumers and Companies**

- The spike in retail propane prices strained budgets for many residential and commercial consumers.[a]
- Propane marketers facing supply shortages "short-filled" customers' storage tanks to spread limited supplies among more consumers.[b]
- High prices pushed many smaller propane marketers to their credit limits, which not only limited their ability to replace propane inventories but forced their customers to pay for their propane on delivery.[c]
- There were a few reports of propane companies walking away from fixed-price contracts with customers who had locked in their delivery price.[d]
- In some areas, propane companies gave priority to hospitals and residential consumers over their industrial and agricultural customers.[e]

[a] http://www.pjstar.com/article/20140204/NEWS/140209688.

[b] http://www.southernminn.com/the_kenyon_leader/news/article_6ec81425-abf1-51d5-84a1-c050628c3ec9.html.

[c] http://news.nationalgeographic.com/news/energy/2014/01/140129-us-propane-shortages-leave-homeowners-in-the-cold/.

[d] http://www.myfoxtwincities.com/story/24710841/propane-shortage-lawmakers-look-for-immediate-help.

[e] http://fox43.com/2014/02/03/propane-shortage-affecting-pa/.

Near record cold temperatures drove up demand for propane during the winters of 2013-2014 and 2014-2015. In 2013-2014 the demand for propane was further boosted in the Midwest by unusually high grain drying demands that occurred later in the year than normal due to a late harvest and wet conditions. At the same time, Midwest supply was limited during the winter of

---

[24] The terms propane and liquefied petroleum gas (LPG) are often used interchangeably. LPG is produced from the processing of natural gas liquids and petroleum refining. Consumer-grade LPG in the United States contains more than 90% propane and the remainder consists of ethane, propylene, butylenes, and various other hydrocarbons. This report uses the term propane throughout.

[25] In this section of the report, the East Coast refers to all of PADD 1 (1A, 1B, 1C), and the Midwest refers to PADD 2.

2013-2014 by infrastructure constraints, supply outages, and rail transportation interruptions. [26] Propane inventories in the Midwest in the winter of 2013/2014 also started the season at below average levels. As propane stocks were drawn down sharply by high demand, supply shortages developed, resulting in rapid increases of spot prices at the Midwest supply hub in Conway, Kansas. [27] Wholesale prices at Conway jumped to nearly $4.90 per gallon in late January, up from about $1 per gallon at the start of the heating season in October 2014. Both State and Federal agencies took urgent actions to address supply issues, including the U.S. Department of Transportation issuing multi-state hours-of-service waivers for truck drivers to move propane into the areas of shortage, and FERC ordering Enterprise Products to provide priority treatment for propane on the company's TEPPCO multi-product pipeline, which supplies parts of the Midwest and Northeast. [28]

In the Northeast — as discussed below — demand similarly jumped in the winter of 2013-2014, reaching consumption levels that set records compared to the previous five winters. However, Northeast supply dynamics allowed adjustments to meet peak demand that were unavailable to the Midwest, notably the availability of marine imports from Western Europe and rail and truck imports from Canada. While Northeast prices saw significant spikes there were relatively fewer supply challenges.

The near record cold temperatures during the winter of 2014-2015 exerted a different impact on propane markets for a number of reasons. The collapse in crude oil prices in the second half of 2014 constrained prices overall. In the Midwest, growth in natural gas liquids production from gas plants brought stocks well above the previous five-year average, grain drying demand during the fall of 2014 was much lower than in 2013, high-demand periods were not as continuous, and there were no major unexpected facilities outages. In the Northeast, production in the Marcellus and Utica shale plays increased regional propane supply. [29]

## Prices

Residential propane prices spiked sharply in the winter of 2013-2014 but were relatively stable in the winter of 2014-2015. Figure 3-1 shows the weekly average retail propane prices in the Midwest and the Northeast between July 2010 and May 2015, comparing them with benchmark spot prices at two regional storage hubs — Mont Belvieu, Texas, and Conway, Kansas — and Brent crude oil prices. Low regional stocks, increased temperature-driven demand, and weather-driven reductions in deliveries drove the weekly wholesale average price in Conway as high as $4.90 per gallon in late January 2014, up from just over $1 per gallon at the start of the winter season. The average weekly residential retail prices followed suit, peaking at or near $4

---

[26] Infrastructure constraints include transportation and production constraints. Transportation infrastructure lacked sufficient pipeline capacity to deliver enough propane to meet demand in the Midwest market. Meanwhile, some production infrastructure was out-of-operation.

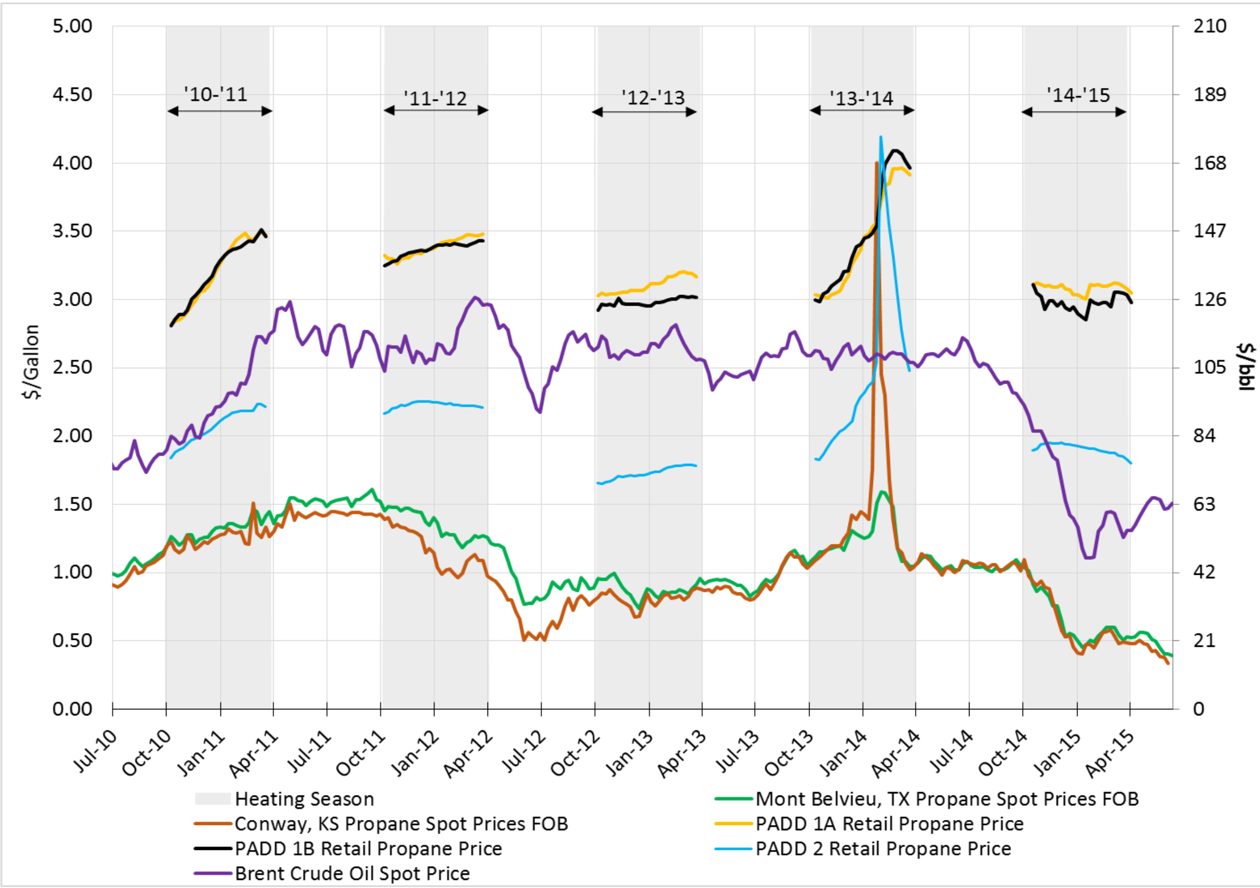
[27] Local demand for propane exceeded local supply. Propane inventory data available at http://www.eia.gov/dnav/pet/pet_sum_sndw_a_epllpz_sae_mbbl_w.htm.

[28] http://www.platts.com/latest-news/oil/houston/enterprise-increasing-teppco-propane-shipments-21198473.

[29] Data available at http://quickstats.nass.usda.gov/.

per gallon in both the Midwest and the Northeast, with press reports indicating that some consumers were paying even higher prices.[30]

*Figure 3-1 Weekly Average Wholesale and Retail Propane Prices: July 2010 – March 2015*




Source: Energy Information Administration, *Spot Prices for Crude Oil and Petroleum Products*, July 2008 – June 2015; *Weekly Heating Oil and Propane Prices*, July 2008 – April 2015.

Propane prices were significantly lower and less volatile in the winter of 2014-2015 than in the previous winter season, despite similar extreme cold spells in January and February 2015. Responding largely to the collapse in crude oil prices in the second half of 2014, spot propane prices at Conway and Mont Belvieu dipped to around 50 cents per gallon by January 2015, down from $1 per gallon at the beginning of the winter season. Residential prices in the Midwest remained below $2 per gallon and exhibited a steady decline throughout the winter. Meanwhile, Northeast propane prices hovered around $3 per gallon throughout the winter but experienced a slight uptick in January and February due to a jump in crude oil prices and the return of extreme cold temperatures to the region.

Normally, propane prices in Conway trade at several cents per gallon below those at Mont Belvieu, reflecting the cost of moving propane by pipeline or rail from Conway to Mont Belvieu.

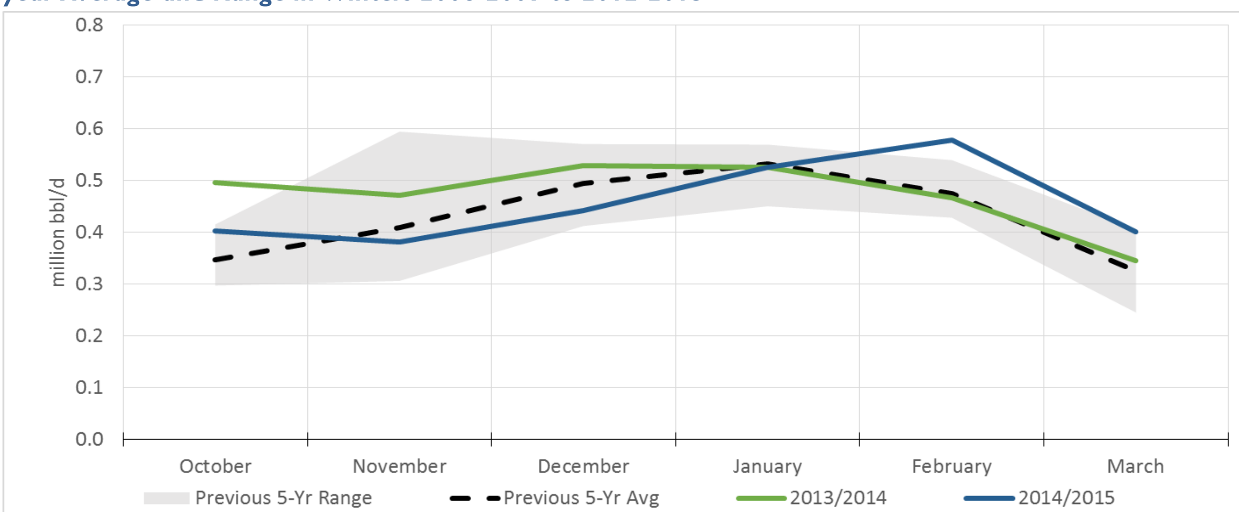
30 http://www.myfoxtwincities.com/story/24710841/propane-shortage-lawmakers-look-for-immediate-help.

However, during peak winter demand periods, Conway becomes a major source of propane supply for the Midwest, with the price at Conway set by demand in the Midwest rather than demand at Mont Belvieu. During the winter of 2013-2014 the spread flipped, with the Conway price spiking to nearly $3.50 per gallon above Mont Belvieu in January 2014, due to the increased demand occurring in the markets largely serviced by Conway.[31] Although the spread quickly receded by the end of February, the spread remained positive during much of the 2014 summer fill season and the fall 2014 harvest season, encouraging propane producers and marketers to hold more stocks in Conway rather than send product to the Gulf Coast.[32]

## Demand

In response to the cold temperatures during the winters of 2013-2014 and 2014-2015, the demand for propane soared in the Midwest and the Northeast. The EIA "Product Supplied" data for propane/propylene represent a proxy for propane demand.[33] Figure 3-2 and Figure 3-3 illustrate propane product supplied in PADD 1 (the East Coast) and PADD 2 (the Midwest), respectively, between July 2008 and March 2015.[34]

***Figure 3-2 PADD 2 (Midwest) Propane Product Supplied in Winters 2013/2014 and 2014/2015 vs. Prior 5-year Average and Range in Winters 2008-2009 to 2012-2013***




Source: Energy Information Administration, Product Supplied (EIA-810, EIA-811, EIA-812, EIA-814, EIA-815, EIA-817), July 2008 – March 2015.

---

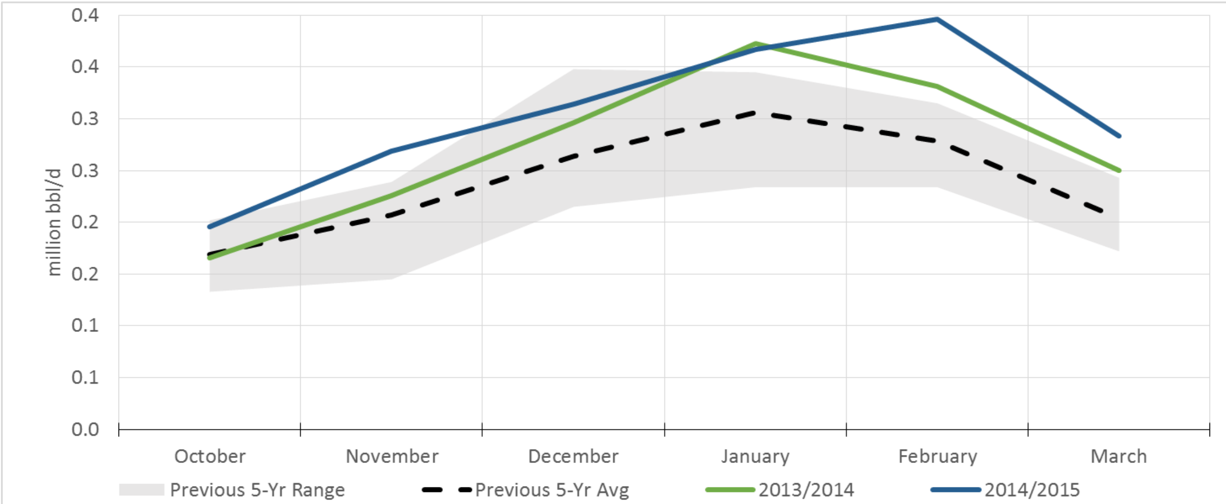
31 Mont Belvieu price data available at http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm. Conway price data available from Bloomberg.

32 Data available at http://quickstats.nass.usda.gov/.

33 The EIA data for "Product Supplied" is a proxy for approximate consumption of petroleum products because it measures the removal of these products from primary sources. However, EIA "Product Supplied" does not account for changes in secondary and tertiary inventories, or account for interregional transportation of propane by truck and rail, hence does not fully capture consumption.

34 The data in this figure include consumption of propane and propylene from the EIA. While small amounts of propylene (less than 5%) are typically blended with propane in consumer-grade propane, propylene is primarily used as a feedstock fuel for the petrochemical industry. For the following regional discussion, this consumption is referred to as propane, even though the data also include propylene.

*Figure 3-3 PADD I (East Coast) Propane Product Supplied in Winters 2013-2014 and 2014-2015 vs. Prior 5-Year Average and Range in Winters 2008-2009 to 2012-2013*




Source: Energy Information Administration, Product Supplied (EIA-810, EIA-811, EIA-812, EIA-814, EIA-815, EIA-817), July 2008 – March 2015.

## Midwest

Average monthly propane demand (product supplied) to the Midwest exceeded 472 thousand barrels per day (Mbbl/d) in the winter of 2013-2014 with peak monthly demand exceeding 525 Mbbl/d. During the winter of 2013-2014, propane demand surged due to near record cold temperatures. In addition, limited available supply and constraints on production and transportation into the region due to the lack of available pipeline capacity led to localized shortages and high prices.[35]

In the winter of 2014-2015, average propane demand in the Midwest decreased by 4% to 454 Mbbl/d from the prior winter season due to lower grain-drying demand (see below) and slightly warmer temperatures. However, the peak monthly consumption — in February 2015 — exceeded the previous winter's high by 50 Mbbl/d.

### Demand for Grain Drying

Grain drying is a major source of propane demand in the Midwest. According to the Propane Education and Research Council (PERC), grain drying in the Midwest requires an average of about 3.8 million barrels of propane per year.[36] Grain drying demand is highly dependent on the moisture content of the corn crop during harvest, and can range from about 1.4 million barrels per year of propane for a dry harvest up to 8.3 million barrels per year during a wet harvest. PERC estimates that in 2013 grain drying demand in the Midwest reached 7.7 million barrels of propane due to a very large corn crop with a high moisture content.[37] Michigan

[35] Based on data provided by Enterprise Pipelines to the Midwest Governors Association, the MAPCO pipeline, which delivers propane from Conway, Kansas to the upper Midwest, was operating at or above capacity during much of the winter of 2013-2014. Available at http://www.midwesterngovernors.org/Propane/JuneMeeting/Presentations/Enterprise.pdf. (Date)

[36] Available at http://www.midwesterngovernors.org/Propane/JuneMeeting/Presentations/Sloan.pdf.

[37] Available at http://www.midwesterngovernors.org/Propane/JuneMeeting/Presentations/Sloan.pdf.

officials estimated that grain drying demand for propane in the Midwest increased by 500% in 2013 relative to 2012.[38] The unusually high demand resulted in a drawdown in propane inventories shortly before the arrival of the winter heating season. In addition, a late corn harvest delayed crop drying until later in the year than normal.[39] Usually, there is a space of three to six weeks between the end of the major grain drying season and the start of the major space heating season, which allows the industry to rebuild secondary and tertiary inventories. However, the arrival of winter before the end of the 2013 crop drying season meant that suppliers did not have this period to replenish customers' stocks.

After the winter of 2013-2014, the propane industry recommended that farmers increase their onsite propane storage capacity, an action that helped mitigate the situation in the winter of 2014-2015.[40] Because the 2014 corn crop arrived earlier and was drier than in 2013, grain drying demand put much less stress on propane markets before the onset of the winter of 2014-2015. As a result, propane deliveries dropped by about 80 Mbbl/d from mid-October through December.[41]

### Northeast

In the winter of 2013-2014, the East Coast, which includes PADD 1A, 1B, and 1C, consumed an average of 274 Mbbl/d of propane (Figure 3-3), with peak-month consumption levels reaching as high as 375 Mbbl/d.[42] Both figures topped those of the previous five winters.

During the winter of 2014-2015, East Coast average propane consumption was higher than during the winter of 2013-2014 winter at more than 300 Mbbl/d due to colder temperatures in the Northeast and lower prices. Peak-month demand reached as high as 400 Mbbl/d in February 2015.

## Supply

### Midwest

The high demand for propane heating fuel in the winter of 2013-2014 required tapping additional sources to avoid a potential shortage in the Midwest, just as a combination of developments in the region was changing the distribution of propane to the region.

One such change was in sources of supply. Traditionally, the Midwest had been a net importer of propane, which it received from a variety of sources, including the MAPPCO and TEPPCO pipelines, the Cochin Pipeline, and rail transportation from Canada.[43] However, due to a boom

---

38 Michigan Residential Heating Oil and Propane Price Survey: 2013-2014 SHOPP Report.

39 Data available at http://quickstats.nass.usda.gov/.

40 See http://www.startribune.com/june-20-minn-farmers-get-a-propane-warning/264065101/.

41 Data available via downloadable files found at http://www.eia.gov/dnav/pet/pet_cons_psup_a_epllpz_vpp_mbblpd_m.htm.

42 The EIA data on propane product supplied does not distinguish PADD sub-regions; therefore, the analysis in this section refers to the entire PADD 1 region, including PADDs 1A, 1B, and 1C.

43 MAPCO is a multi-product pipeline system that connects the propane storage hub at Conway, Kansas with the upper Midwest, including Nebraska, Iowa, Illinois, Wisconsin, and Minnesota. TEPPCO is a multi-product pipeline system that connects the propane storage hub in Mont Belvieu, Texas, with markets in Missouri, Illinois, Indiana, and Ohio before extending into the Northeast.

in shale gas production beginning in 2012, particularly from the Bakken formation in North Dakota, the region itself was producing an increasing share of its propane requirements.[44]

At the same time, as a result of similarly growing propane production in the Northeast, in 2013 the flow in a portion of the TEPPCO pipeline was reversed to ship ethane from the Northeast to the Gulf Coast, reducing the pipeline's capacity to ship refined products to both the Midwest and Northeast. Meanwhile, another key source of propane for the Midwest was virtually eliminated when the propane capacity in the Cochin pipeline was reduced to 50 Mbbl/d from its previous capacity of 78 Mbbl/d, just ahead of the winter of 2013-2014, followed by a three-week closure of the Cochin pipeline beginning November 30, 2013.[45] The result was that non-Midwest sources of supply had diminished, and there was less excess capacity into the region. These changes reduced the flexibility needed to respond to the winter of 2013-2014 shortage, when demand increased and unexpected supply outages at the Tioga Gas Plant in North Dakota (production capability of about 8Mbbl/d), and the Rapid River fractionation facility in Michigan (production capability of about 48Mbbl/d) reduced regional production of supply.[46] [47]

Figure 3-4 illustrates these changes. It shows Midwest propane consumption over five years against sources of supply, including the production from refineries and gas plants, net movements from other regions, and imports. The figure demonstrates that an increasing share of Midwest propane supply came from in-region production in the winters of 2013-2014 and 2014-2015.[48] Since 2012, the growth in Midwest supply from in-region production had largely crowded out other sources of supply, such as movements from other regions, imports, and stock withdrawals. In the winter of 2013-2014, the Midwest's monthly average production of propane was approximately 297 Mbbl/d, or 39% of the average monthly consumption in the region during that winter. As a comparison, in the winter of 2014-2015, the monthly average production was nearly 554 Mbbl/d, meeting approximately 55% of that winter's monthly average consumption in the Midwest. Correspondingly, average monthly net imports into the Midwest were reduced by nearly 30 Mbbl/d between the two winters, largely due to the permanent closure and reversal of the Cochin pipeline in April 2014 (see case study at the end of the chapter). In addition, during the height of the winter of 2013-2014 shortage, the major pipeline into the Midwest from Conway, the MAPCO system was flowing at or above capacity, limiting the ability to increase pipeline flows of propane into the region.[49]

---

[44] Propane production in the upper Midwest doubled from 22 Mbbl/d in 2012 to 44 Mbbl/d in 2014. By May of 2015, propane production in the region had increased to 68 Mbbl/d. http://www.eia.gov/dnav/pet/pet_pnp_gp_dc_r2b_mbblpd_a.htm.

[45] http://www.lpgasmagazine.com/three-week-shutdown-coming-to-cochin-pipeline/.

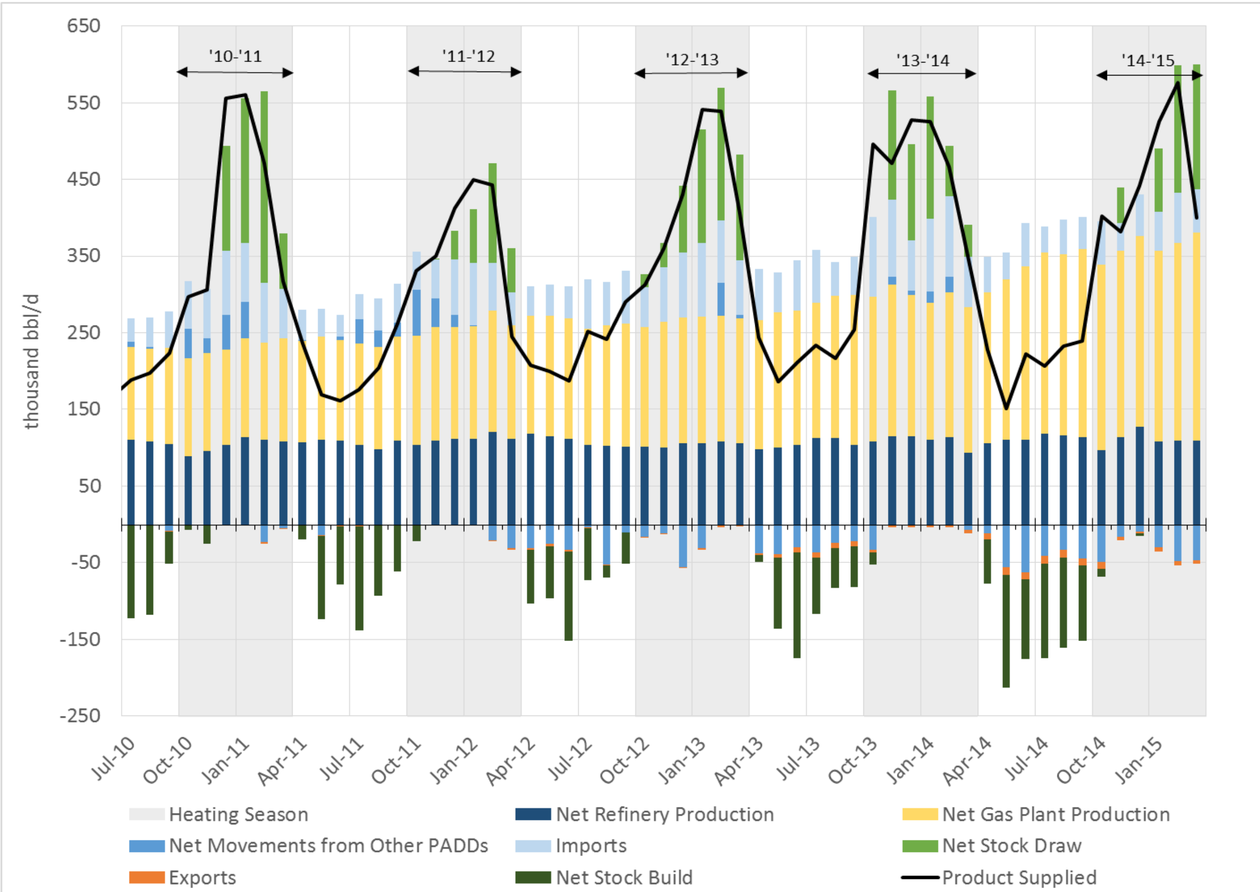
[46] NPGA congressional testimony, March 6, 2014. Available at: http://docs.house.gov/meetings/IF/IF03/20140306/101847/HHRG-113-IF03-Wstate-RolandR-20140306.pdf.

[47] Michigan Residential Heating Oil and Propane Price Survey: 2013-2014 SHOPP Report.

[48] What drives the difference between supply and consumption is attributed to stock withdrawals when consumption is higher than supply and stock build-up or exports when supply is higher than consumption.

[49] Available at http://www.midwesterngovernors.org/Propane/JuneMeeting/Presentations/Enterprise.pdf.

***Figure 3-4 Propane Product Supplied and Sources of Supply to the Midwest (PADD 2): July 2010 – March 2015***




Source: Energy Information Administration, Product Supplied, Net Refinery Production, Net Gas Plant Production, Net Movements by Tanker and Barge, Imports by Processing Area, and Exports (EIA-810, EIA-811, EIA-812, EIA-814, EIA-815, EIA-816, EIA-817), July 2010 – March 2015.

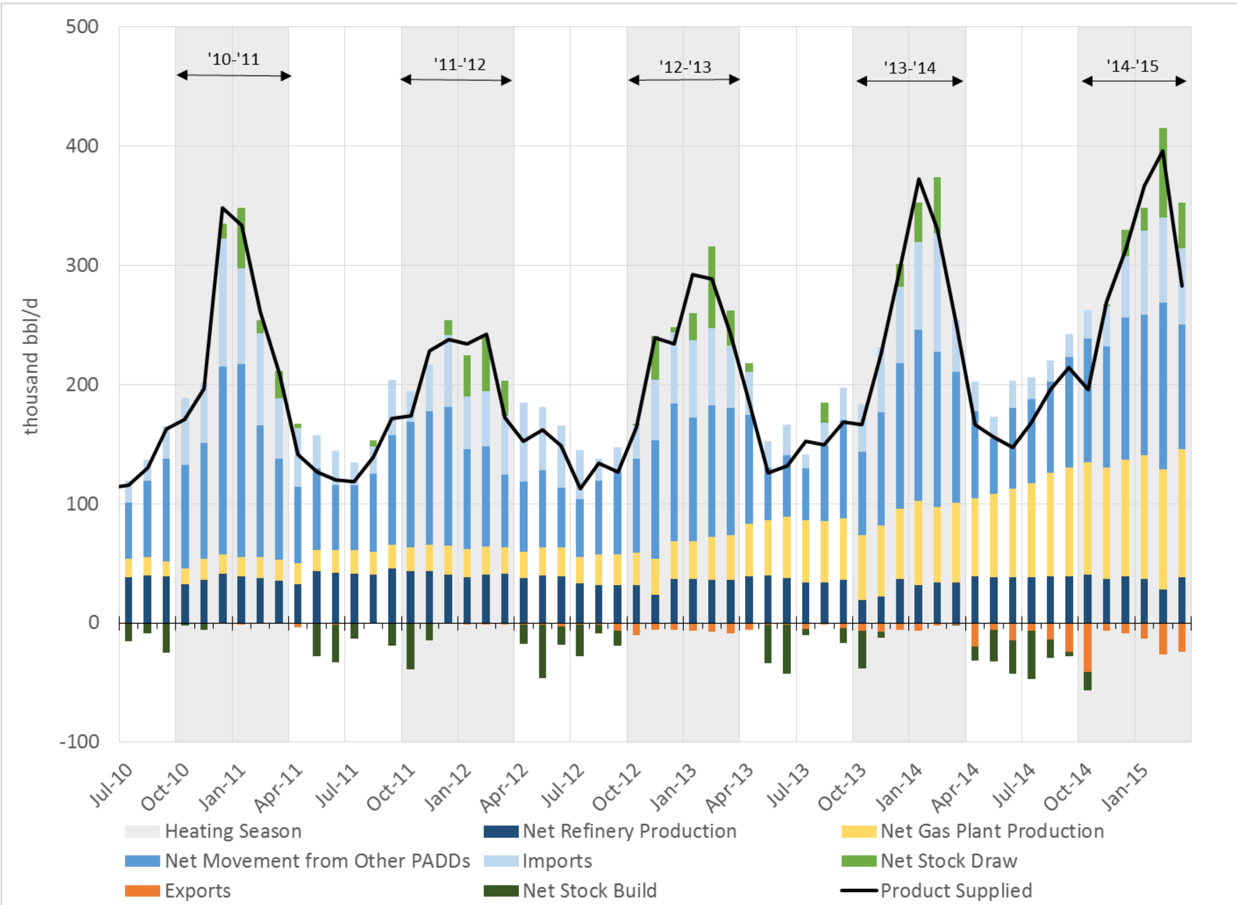
In sum, despite the growing production in the Midwest, the resulting dependence on Midwest propane supply and diminishing access to sources in other regions left the Midwest with fewer supply options therefore reduced flexibility to meet a supply crisis in the winter of 2013-2014. Due to unrelenting cold weather conditions during the winter of 2013-2014, combined with a diminished propane inventory at the Conway market hub, the industry experienced an extended period of tight supplies and high prices.

Overall, regional supply increased significantly between the winters of 2013-2014 and 2014-2015 due to the increase in natural gas liquids production, as well as the lack of any major unexpected production outages. As a result, despite the loss of capacity resulting from the reversal of the Cochin Pipeline, overall supply in the region increased, and the region was better positioned to meet the peaks in demand that occurred during the winter of 2014-2015.

## Northeast

Adjustments in Northeast supply dynamics enabled the region to meet peak demands during the winter of 2013-2014. Figure 3-5 shows the supply portfolio of the East Coast (PADD 1), which includes the Northeast, Mid-Atlantic, and South Atlantic regions.[50]

***Figure 3-5 Propane Product Supplied and Sources of Supply to the East Coast (PADD 1): July 2010 – March 2015***




Source: Energy Information Administration, Product Supplied, Net Refinery Production, Net Gas Plant Production, Net Movements by Tanker and Barge, Imports by Processing Area, and Exports (EIA-810, EIA-811, EIA-812, EIA-814, EIA-815, EIA-816, EIA-817), July 2010 – March 2015.

During the winter of 2013-2014, propane production on the East Coast (PADD 1) averaged 92 Mbbl/d, which accounted for approximately 34% of the region's average winter consumption. The balance was supplied by movements from other regions, rail and truck imports from Canada, marine imports from other countries, and stock withdrawals. Imports provided a key source of swing supply in the winter of 2013-2014. Net imports during that winter averaged 62 Mbbl/d, with peak net volumes exceeding 99 Mbbl/d in February 2014.

---

50 The EIA data on propane product supplied does not distinguish PADD sub-regions; therefore, the analysis in this section covers the entire PADD 1 region, including PADDs 1A, 1B, and 1C.

In the winter of 2014-2015, propane production on the East Coast (PADD 1) increased to 136 Mbbl/d, representing approximately 45% of the total consumption. The growth was due to increased production from natural gas plants in the Marcellus and Utica shale plays. However, exports from the region also increased with expanding marine exports from Marcus Hook and transportation to the Midwest and Gulf Coast.

Despite colder temperatures in the Northeast in the winter of 2014-2015 compared to 2013-2014, net imports fell by 50% to an average of 25 Mbbl/d. Further discussion on imports and their role in providing swing supply to the Northeast is discussed in the Imports section of this chapter.

### Federal and State Responses to the Supply Shortages During Winter of 2013-2014

During the winter of 2013-2014, most of the States in the affected regions issued hours-of-service waivers for truck drivers, and the U.S. Department of Transportation issued waivers for regional truck drivers in 36 States and the District of Columbia, allowing drivers to work longer hours in order to move extra propane supplies into the areas of shortage. This facilitated truck transport of additional propane supplies into the Midwest and Northeast from storage hubs as far as away as Mont Belvieu, Texas, and Hattiesburg, Mississippi, providing a measure of relief to propane-dependent consumers in the Midwest and the Northeast.[51]

On February 7, 2014, in another effort to alleviate the propane shortages in the Midwest and Northeast, the Federal Energy Regulatory Commission (FERC) invoked its emergency authority under the Interstate Commerce Act to direct Enterprise TE Products Pipeline Company, LLC (TEPPCO) to temporarily provide priority treatment to propane shipments from Mont Belvieu, Texas.[52] In response to the FERC order, approximately 18 Mbbl/d of supply was added to the TEPPCO pipeline supplying the Midwest and Northeast. This was the first time that FERC had used this emergency authority for any reason.[53]

## Stock Drawdowns

### Midwest

Low propane stocks in the Midwest at the start of the 2013-2014 heating season set the stage for propane shortages in that region later that winter. Figure 3-6 and Figure 3-7 show the propane inventory levels in the Midwest (PADD 2) and East Coast (PADD 1) during the winters of 2013-2014 and 2014-2015, compared with the seasonal five-year average and high-low ranges between 2008 and 2012. Heavy propane use for grain drying during fall of 2013 slowed inventory builds in September and sharply drew down inventories in October and November at a time when inventories are typically flat or slightly declining. Despite relatively normal fall weather, Midwest propane stocks declined by nearly 6 million barrels from the beginning of October through the end of November of 2013, compared to an average decline of roughly 1–2 million barrels in those same months in each of the previous five years.

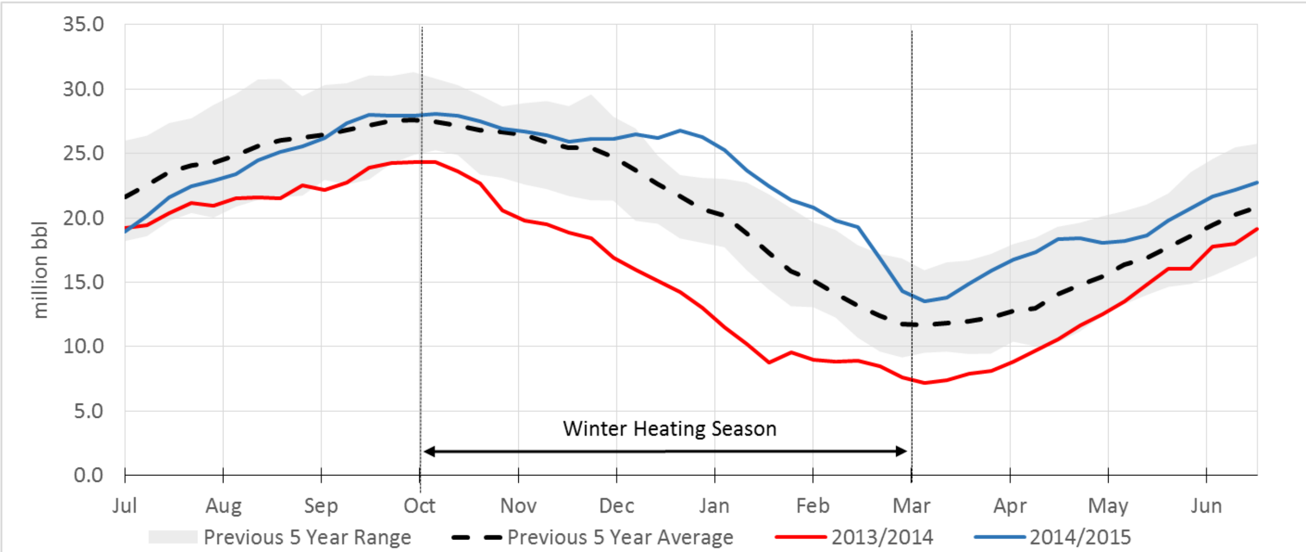
---

[51] http://www.reuters.com/article/2014/01/21/us-energy-us-propane-idUSBREA0K1I920140121.

[52] Available at: https://www.ferc.gov/CalendarFiles/20140207183308-OR14-20-000.pdf.

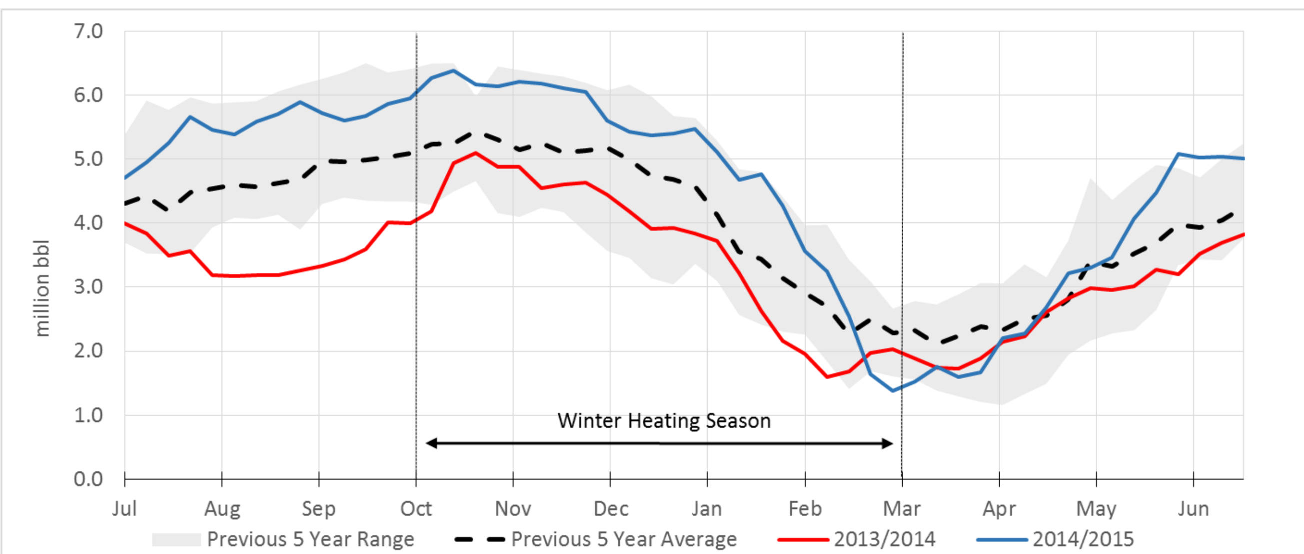
[53] Available at: http://www.platts.com/latest-news/oil/houston/enterprise-increasing-teppco-propane-shipments-21198473.

*Figure 3-6 Midwest (PADD 2) Propane Inventories, 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013*




Source: Energy Information Administration, *Total Stocks (EIA-800, EIA-801, EIA 802)*, July 2008 – June 2015.

*Figure 3-7 East Coast (PADD 1) Propane Inventories, 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013*




Source: Energy Information Administration, *Total Stocks (EIA-800, EIA-801, EIA 802)*, July 2008 – June 2015.

When the demand began to increase at the onset of cold temperature in the winter of 2013/2014, suppliers had relatively little inventory to meet increased demand and buffer supply uncertainties, as described in the previous section. By the beginning of January 2014, when extreme cold began to permeate the region, Midwest propane stocks stood at 13 million barrels – 5 million barrels below the low for the same period over the previous five years.

Following the large drawdown in stocks in the winter of 2013-2014, the Midwest began rebuilding inventories at a rapid pace as the price in Conway, Kansas traded at a premium to Mont Belvieu, Texas, during most of summer 2014.[54] By September 2014, stocks had climbed above the previous five-year average. Booming in-region production kept stocks stable throughout October and November. Stocks increased during a relatively warm December, bringing them well above the previous five-year range before the return of extreme cold temperatures in January and February 2015. High heating demand in these months led to sharp stock drawdowns; however, inventories remained solidly above the five-year average for the remainder of the winter of 2014-2015. In fact, even during the coldest months of the winter, the Midwest remained a net exporter of propane to other regions.

### East Coast[55]

Primary propane storage capacity on the East Coast is relatively limited. As shown in Figure 3-7, stocks on the East Coast stood at 3.8 million barrels in October 2013 at the start of the 2013-2014 winter heating season — above the low for the same period over the previous five years but below the previous five-year average. The East Coast entered the winter of 2014-2015 with inventories tracking near the top of the previous five-year range; however, extreme cold, which was worse in the Northeast than the Midwest, led to a sharp drawdown in stocks in January and February 2015. Despite having entered the heating season 2 million barrels above 2013-2014 season levels, East Coast stocks dipped below the previous winter's levels in late February and early March 2015.

---

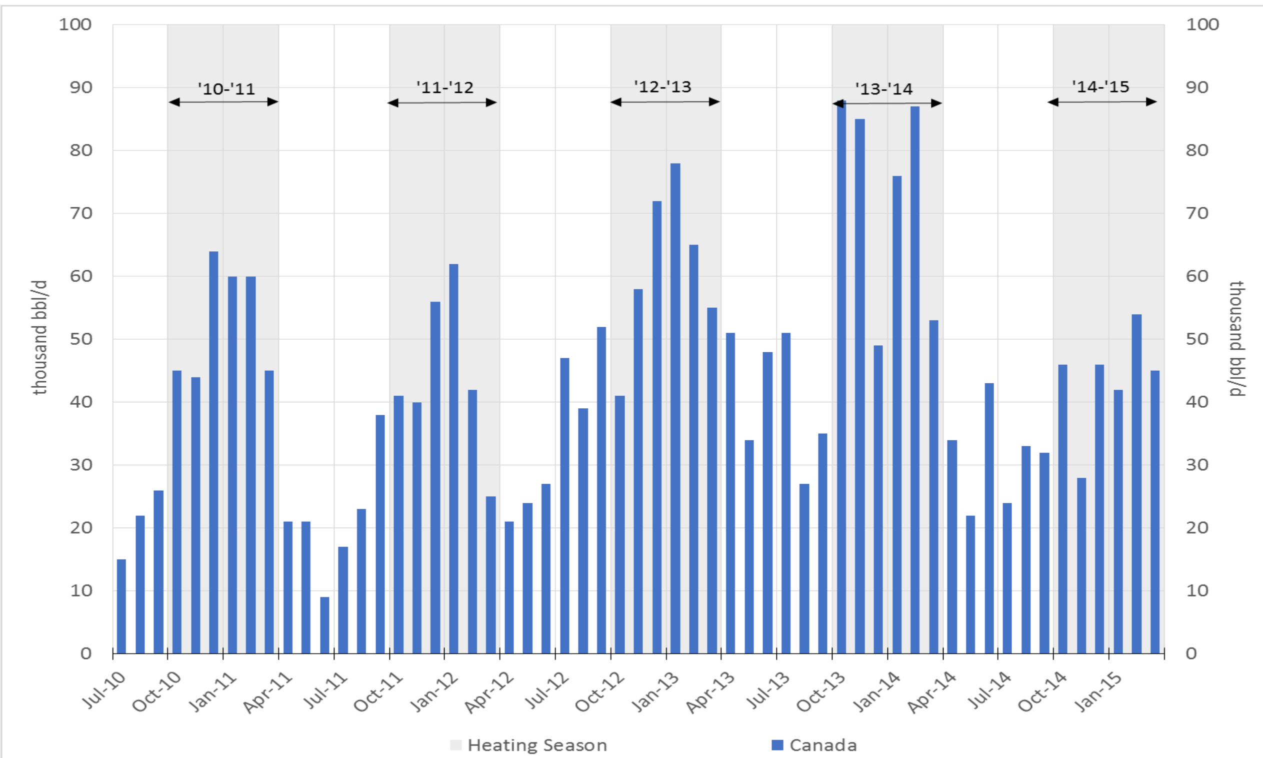
[54] Mont Belvieu price data available at http://www.eia.gov/dnav/pet/pet_pri_spt_s1_d.htm. Conway price data available from Bloomberg.

[55] EIA reports propane inventory data for PADD 1, which includes the Northeast, Mid-Atlantic, and South Atlantic regions.

## Imports

Imports from Canada provided an important source of incremental supply into the Midwest in the winter of 2013-2014. Figure 3-8 shows gross propane imports into the Midwest by source from July 2008 to March 2015. The winter of 2013-2014 saw an average of 103 Mbbl/d of gross propane imports, much of which flowed via the Cochin Pipeline from Western Canada (see case study box at the end of the chapter). Canadian import volumes in the winter of 2014-2015, following the Cochin flow reversal, dropped to 67 Mbbl/d.

*Figure 3-8 Midwest (PADD 2) Imports of Propane from Canada: July 2010 – March 2015*

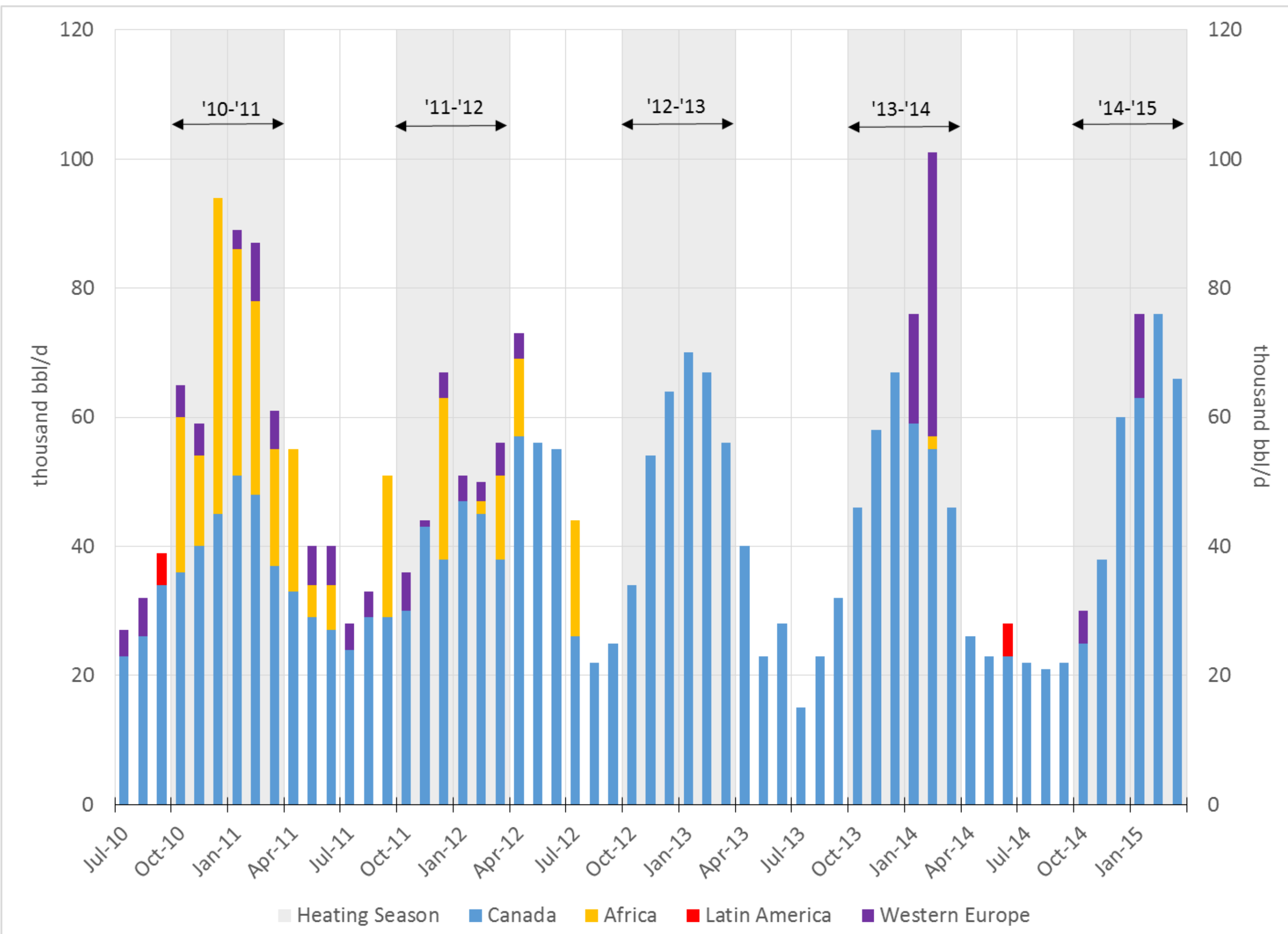



Source: Energy Information Administration, Imports by Processing Area (EIA-814), July 2010 – March 2015.

The Northeastern U.S. relies on propane imports from Canada, primarily by rail and truck, as well as marine imports from Western Europe and, to a lesser extent, Africa. Marine imports from Western Europe provided a key source of swing propane supply to the East Coast (PADD 1) in January and February 2014 as high prices in the United States and relatively low prices in Europe attracted cargos from across the Atlantic.

Figure 3-9 shows gross propane imports into the East Coast since 2008. Since 2012, imports into this region from countries other than Canada have fallen to essentially zero as they have been displaced by increasing domestic and Canadian production transported primarily by rail. However, the extreme cold in early 2014 drew in a surge of imports from Western Europe, adding 17 and 44 Mbbl/d to East Coast supply in January and February respectively. The imports primarily arrived at two terminals in New England, which had not received marine cargoes since 2012. At their peak in February 2014, total gross imports into the Northeast from all countries by marine, rail, and truck exceeded 100 Mbbl/d. Overall gross propane imports in the 2013-2014 heating season averaged 66 Mbbl/d. Despite colder Northeast temperatures during the winter of 2014-2015, gross import levels dropped off to 58 Mbbl/d with very few imports arriving from Western Europe.

*Figure 3-9 East Coast (PADD 1) Imports of Propane by Country: July 2010 – March 2015*



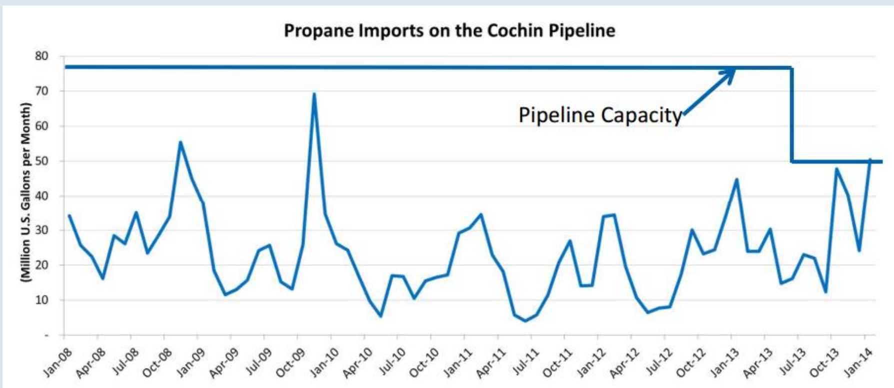

Source: Energy Information Administration, Imports by Processing Area (EIA-814), July 2010 – March 2015.

## Reversal of the Cochin Pipeline and its Effect on Midwest Propane Markets

Prior to April 2014, the Cochin Pipeline provided a direct connection between the Midwest and the 5.2 million barrels of propane storage capacity in Alberta, Canada. The pipeline had a propane capacity of 78 Mbbl/day (reduced to 50 Mbbl/d in 2013 ahead of the 2013-2014 winter season) and delivered a major portion of propane supply from Western Canada to the Midwest.

In April 2014, the Cochin Pipeline was repurposed and reversed to flow diluent from the Midwest to the oil sands of Western Canada. The Cochin Pipeline was shut down for three weeks during December 2013 as part of the reversal process, limiting propane flows into the Midwest from Canada during this time period.

Before the reversal, the pipeline generally operated at below maximum capacity, even during the winter months. As a result, the pipeline provided swing capacity to deliver propane into the U.S. Midwest to meet peak demand during the fall grain-drying season and winter heating season.




Source: Impact of the Cochin Pipeline Reversal on Consumer Propane Markets in the Midwest, ICF International. Prepared for the Propane Education and Research Council, August 2014.

The impacts of the Cochin Pipeline reversal for the Midwest include the loss of a major source of supply, the loss of swing capacity to meet peak grain-drying and cold weather demand, the loss of access to Canadian storage, and an increased reliance on other supply sources, particularly rail deliveries from Western Canada and the Bakken region of North Dakota. The 2014 study prepared by ICF International for the Propane Education Research Council (PERC) estimated that 65 to 100 incremental rail car deliveries would be required each day to supply the Midwest during peak demand periods.

To replace the Cochin Pipeline, CHS and other companies substantially expanded rail terminal capacity in the markets previously served by the pipeline, and Canadian companies, including Plains and Keyera, have expanded rail terminal capacity in Alberta. An additional source of the Midwest's propane needs has been provided by growth in propane production and natural gas fractionation from the Bakken region in North Dakota.

*This page intentionally blank*

# 4. Natural Gas Markets

## Summary

This section examines natural gas supply, demand, and prices to gain better understanding of the operating challenges faced by the U.S. natural gas market during the winters of 2013-2014 and 2014-2015. These data can provide important insights into the relationship between natural gas markets and power markets, a topic which is the subject of both industry and regulatory activity.

The U.S. natural gas market is well-developed, transparent and liquid, with competitive trading at dozens of market centers ("hubs") located across the country. These trading hubs are linked by an extensive, highly integrated pipeline network. Natural gas demand normally peaks during winter months due to increased gas use for space heating in residential and commercial buildings, and demand during these two winters was pushed even higher by the extreme weather conditions.

The winters of 2013-2014 and 2014-2015 were both colder than average, resulting in natural gas demand that was well above typical winter levels. Compared to the average of the prior five winters (2008-2009 to 2012-2013), residential and commercial gas consumption were about 15% higher in 2013-2014 and 10% higher in 2014-2015.

As low temperatures swept across most of the Eastern United States, natural gas producers, pipelines and local distribution companies (LDCs) were able to deliver gas supplies to meet residential and commercial customer demands.

There are two general classes of natural gas customers, firm and interruptible. In contrast to the firm customers, interruptible customers forgo the higher cost of firm transportation service contracts and instead rely on pipeline capacity that is released on days when firm shippers are not using their full contracted capacity. The majority of gas-fired electric generators in the Eastern Interconnect (which includes most of the Midwest, all of the Northeast, and most of the South, excluding parts of Texas) rely on interruptible pipeline capacity to meet their fuel needs.[56]

As natural gas's share of total electricity generation has increased, electricity systems have become more reliant on gas-fired generation to meet electricity demand throughout the year, not just during summer months when interruptible gas pipeline capacity is usually plentiful. While electricity demand is not as high in winter months as it is in summer months, electricity

[56] Eastern Interconnect Planning Collaborative, Phase 2 Report: Interregional Transmission Development and Analysis for Three Stakeholder Selected Scenarios and Gas-Electric System Interface Study, Volume 1 Executive Summary and Condensed Report, July 2, 2015.

demand tends to increase on very cold winter days, which can lead to increased power sector demand at the same time residential and commercial gas demands are peaking.

During the winter of 2013-2014, the increased demand caused by the extreme cold tightened the overall U.S. supply/demand balance, resulting in higher natural gas spot prices throughout the country. During the winter of 2013-2014, spot prices at Henry Hub (generally considered to be indicative of overall U.S. price trends) averaged $4.44/MMBtu, about 25% higher than the prior 12-month period.[57] However, the highest and most volatile prices occurred in the Northeast and Midwest, where interruptible pipeline capacity was most constrained. During the winter of 2013-2014, spot gas prices in New York City averaged over $10/MMBtu and spiked to a daily record high of $121/MMBtu; similar record highs were seen in market areas up and down the East Coast. In Chicago, spot prices averaged nearly $7/MMBtu and peaked at over $41/MMBtu.

However, spot prices in the Marcellus Shale (a major natural gas production area stretching from West Virginia through Pennsylvania) averaged just over $4/MMBtu and peaked at $8.46/MMBtu. The price differentials between the Marcellus Shale and nearby market areas along the East Coast demonstrate the potential impacts of pipeline constraints between the two areas. While prices also rose in the West and the South during the winter of 2013-2014, they were generally neither as high nor as volatile as in the Northeast and Midwest.

Compared to the winter of 2013-2014, spot prices during the winter of 2014-2015 were lower in most markets. The Henry Hub spot price peaked around $4.50/MMBtu in November 2014, but hovered around $3/MMBtu for most of the winter. When daily price spikes did occur in the Northeast and Midwest, they were not as high as those observed in 2013-2014. In New York City, spot prices averaged under $6/MMBtu and peaked at just under $38/MMBtu.

The lower prices and reduced price volatility observed during the winter of 2014-2015 were due to a combination of factors that eased the supply/demand balance throughout the country, and particularly in the Northeast and Midwest markets:

- The periods of cold weather during the winter of 2014-2015 were neither as long in duration nor as widespread as during the 2013-2014 winter; as a result, residential and commercial demand in some key market areas was not as high in 2014-2015, and so more pipeline capacity was available to interruptible customers.
- Increased domestic gas production, mostly due to growth in output from the Marcellus Shale, provided additional gas supplies. Total U.S. gas production averaged over 8 billion cubic feet per day (Bcf/d) higher during the winter of 2014-2015, a 9% increase over the winter of 2013-2014.
- Natural gas storage is also an important component of U.S. winter supplies. The winter of 2014-2015 began with much milder weather in December, so early season gas storage withdrawals were relatively low. As a result, storage inventories as of the first week of January 2015 were almost 10% higher than in January 2014, providing additional supplies in the later months of winter.

While more difficult to quantify, another factor contributing to reduced prices and reduced price volatility observed during the winter of 2014-2015 was a change in the expectations of

57 Unless otherwise noted, natural gas prices cited throughout this document are based on spot market price data from Ventyx Energy Velocity Suite.

market participants.  Prior to the winter of 2013-2014, the U.S. had not seen a significantly colder-than-normal winter for over 10 years, and had recently experienced the warmest winter on record (winter of 2011-2012).  After the price shocks of the 2013-2014 winter, market participants recognized that the potential still existed for high and volatile natural gas prices, and preemptive measures were taken prior to the winter of 2014-2015 which helped moderate average prices and dampen daily price volatility.  For example, ISO New England expanded its Winter Reliability Program (which incentivizes electricity generators to have alternate fuels available) to include LNG, prompting increases in imports to the Everett and Northeast Gateway terminals during the winter of 2014-2015.[58]

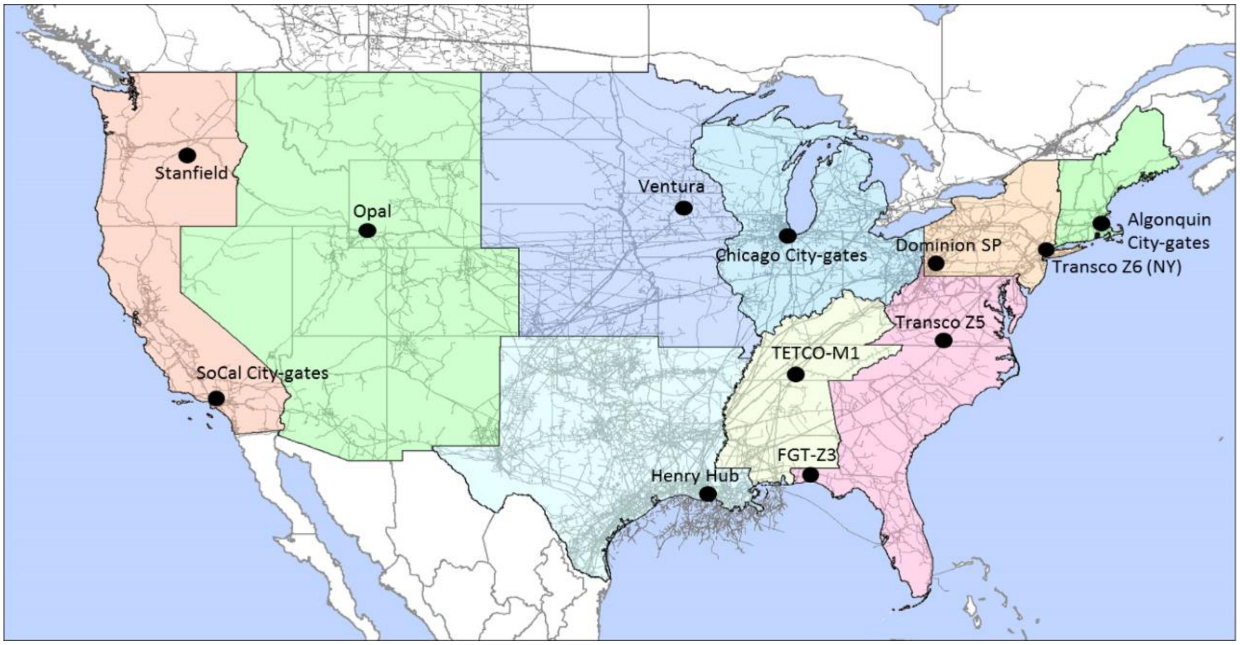
The sections that follow provide a more detailed look at prices, and the demand and supply fundamentals that shape them.

## Spot Prices

Natural gas spot prices — expressed in $/MMBtu — are formed through trading at hubs across the U.S. pipeline network, and are reported daily in a wide range of industry publications and data services. The most commonly used reference point for natural gas prices is Henry Hub, a major pipeline distribution hub in South Louisiana. In this section, selected key natural gas pricing points representing each Census region (shown in Figure 4-1) are reviewed, and the daily and average price levels for the winters of 2013-2014 and 2014-2015 are compared with the previous five winters. Because the natural gas market is both efficient and transparent, natural gas price behavior can provide valuable insights into the underlying regional supply and demand conditions discussed in the sections that follow.

[58] ISO New England's Winter Reliability Program was designed to ensure there were adequate fuel supplies for dual-fuel resource capability by creating incentives offsetting the carrying costs of unused firm fuel purchased by generators, and providing compensation for demand response services. FERC Order Accepting Tariff Revisions, Docket Nos. ER14-2407-000-002. ISO New England, Inc. and New England Power Pool Participants Committee. September 9, 2014.

*Figure 4-1 Pricing Points for U.S. Regional Natural Gas Markets at Selected Pipeline Delivery Hubs*




Source: Ventyx. See Glossary for Descriptions of Major U.S. Pipeline Pricing Hubs.

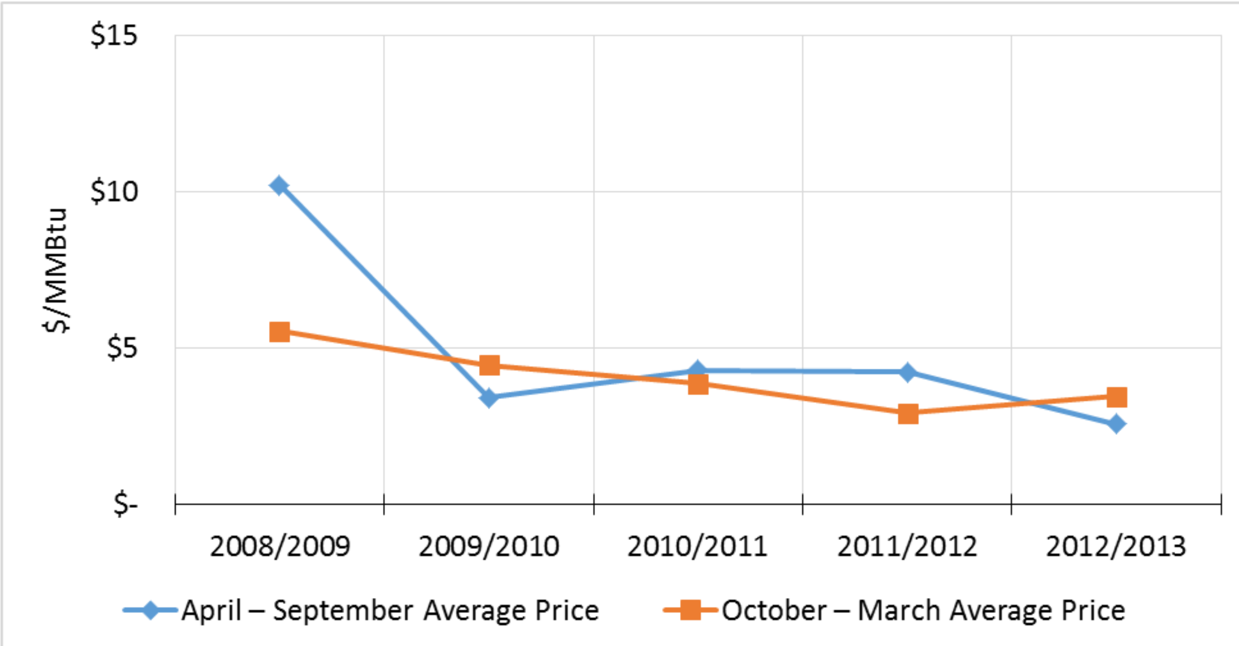
Increased gas demand for space heating during the winter is a fundamental driver of variations in gas prices. Typically, natural gas prices in the United States are higher in the winter months as space heating demand increases. However, in the year leading up to the winter of 2013-2014, weak demand (due to mild winter weather and slow economic growth) and strong growth in shale gas production combined to suppress the typical seasonal price pattern. In three of the five years prior to the winter of 2013-2014, Henry Hub winter spot prices averaged *lower* than the average of the prior spring, summer, and fall prices, as shown in Figure 4-2.

**Impact of Short-term Spot Gas Price Spikes on Consumer Energy Costs**

Local Distribution Companies use long-term firm contracts for most of their natural gas supplies, and purchase only a small percent of their total supply portfolio on the spot market. Therefore, short-term spikes in natural gas spot prices have very little impact on residential and commercial gas bills.

In contrast, electric generators in many states rely on spot markets to meet most of their natural gas needs. When spot prices spike, the higher fuel costs are passed through to electricity customers.

*Figure 4-2 Average Seasonal Henry Hub Natural Gas Spot Prices ($/MMBtu): 2008-2009 to 2012-2013*




Source: Ventyx.

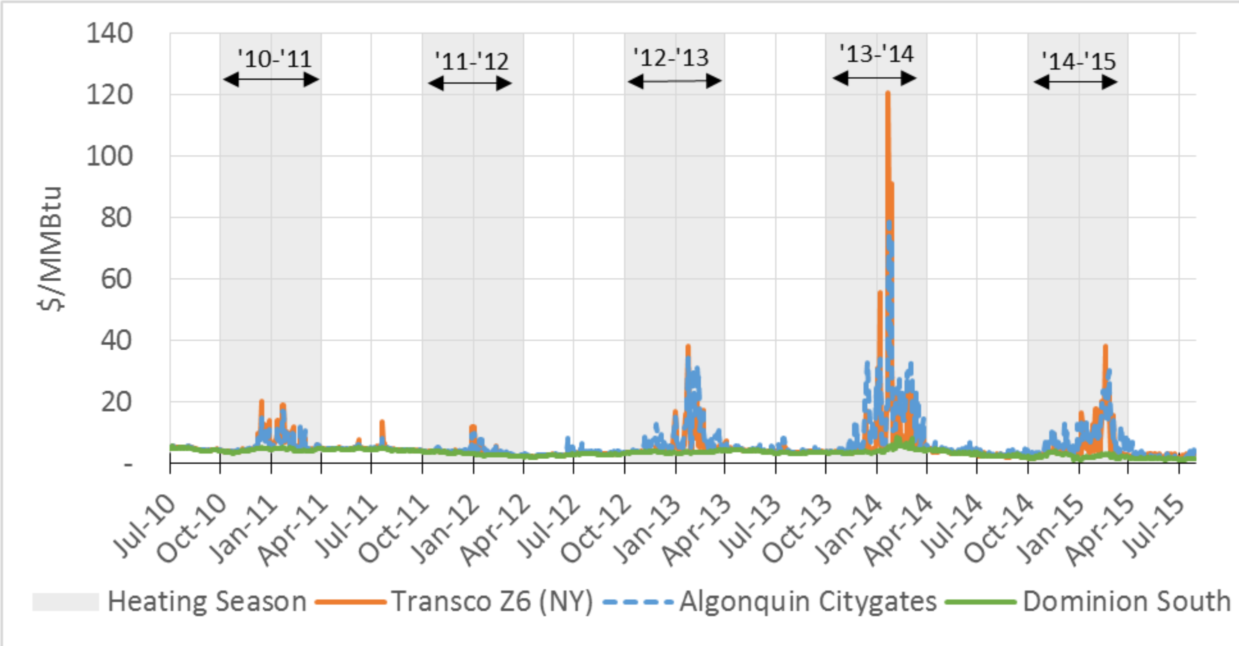
Average daily prices are typically associated with the availability of gas *supply* to a market and the market's ability to endure a protracted cold winter through a diversified and adequately designed portfolio of resources. It is typically useful to compare seasonal prices to recent seasonal averages. This can shed light on important underlying trends in demand, supply, or infrastructure.

### Northeast (New England and Mid-Atlantic)

New England and Mid-Atlantic comprise one of the largest residential and commercial natural gas demand markets in the United States. Because of the seasonality of residential and commercial demand, regional prices typically command a premium in the winter over other parts of the country. With the emergence of production from the Marcellus Shale, however, prices in the region have exhibited a West-East divide: New England states, New York City and Northern New Jersey, located at the end of natural gas pipeline transportation systems, have often experienced pipeline delivery constraints on cold winter days while Pennsylvania has emerged as a large supply center where natural gas prices often trade at a significant discount to the Henry Hub price.

Figure 4-3 and Table 4-1 show that natural gas prices in the Northeast market centers, Algonquin city-gate at Boston, and Transco Zone 6 NY at New York City, were much higher and more volatile in the winters of 2013-2014 and 2014-2015 than in the previous years. Northeast gas prices spiked to nearly $121/MMBtu in New York City and $79/MMBtu in Boston on January 21 and January 22, 2014. Price spikes returned but were less pronounced in the winter of 2014-2015, peaking at $38/MMBtu in New York City and $30/MMBtu in Boston.

*Figure 4-3 Daily Natural Gas Prices ($/MMBtu) in Mid-Atlantic and New England Regional Markets: July 2010 – July 2015*




Source: Ventyx.

*Table 4-1 Northeast Winter (Heating Season) Price Statistics by Period, Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average in Winters 2008-2009 to 2012-2013*

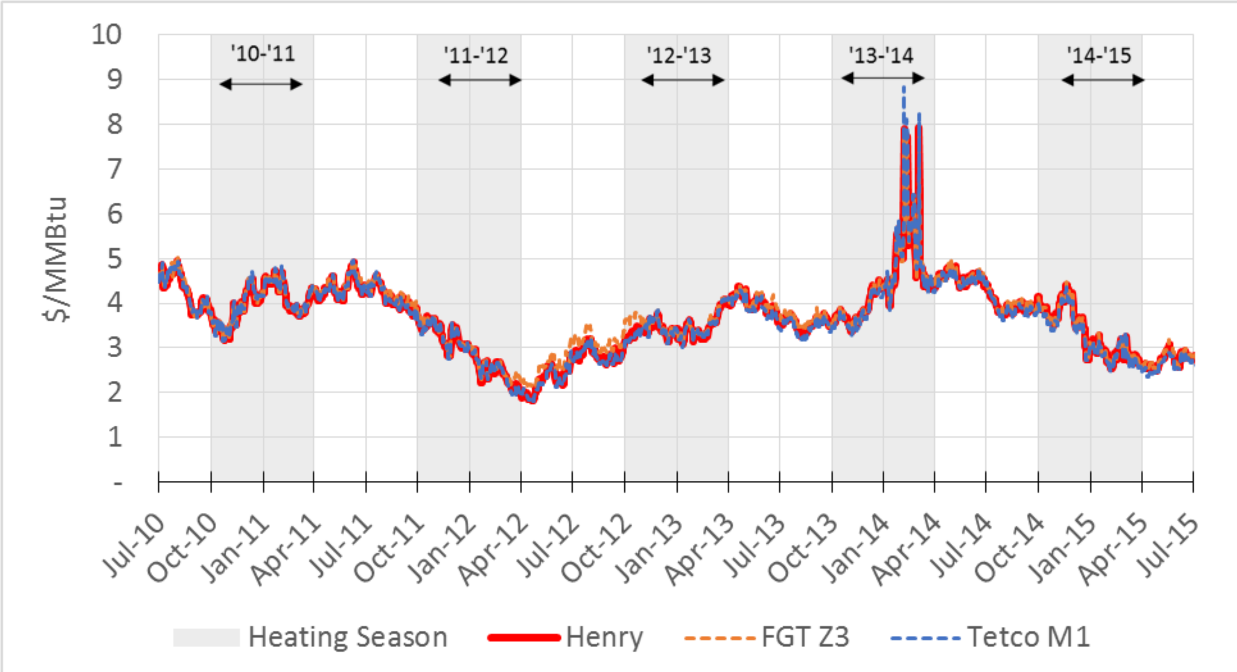
| | Transco Z6 (NY) | | Algonquin Citygates | | Dominion SP | |
|---|---|---|---|---|---|---|
| | Peak Day | Avg. | Peak Day | Avg. | Peak Day | Avg. |
| **Average of Heating Season 2008-2009 through 2012-2013** | 20.09 | 5.81 | 17.45 | 6.25 | 5.65 | 4.29 |
| **Heating Season 2013-2014** | 120.70 | 10.09 | 78.64 | 13.78 | 8.46 | 4.11 |
| **Heating Season 2014-2015** | 37.90 | 5.92 | 30.02 | 8.16 | 3.83 | 2.22 |

Source: Ventyx.

## South (West South Central, East South Central, and South Atlantic)

As the reference point for most North American natural gas transactions, the Henry Hub price generally reflects the market's supply and demand balance. As shown in Figure 4-4 and Table 4-2, during the winter of 2013-2014 prices at Henry Hub averaged $4.45/MMBtu, 9% higher than the previous five-year period. Spot prices on February 5 and March 4, 2014 reached $7.91 and $7.92/MMBtu respectively, the highest recorded since 2008. Both spot price peaks occurred amid widespread cold weather affecting most parts of the country, which drove up demand for natural gas.

*Figure 4-4 Daily Natural Gas Prices ($/MMBtu) in South Central and Southeast Regional Markets: July 2010 – July 2015*




Source: Ventyx.

*Table 4-2 Winter Natural Gas Prices in Southern Markets, $/MMBtu, Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average in Winters 2008-2009 to 2012-2013*

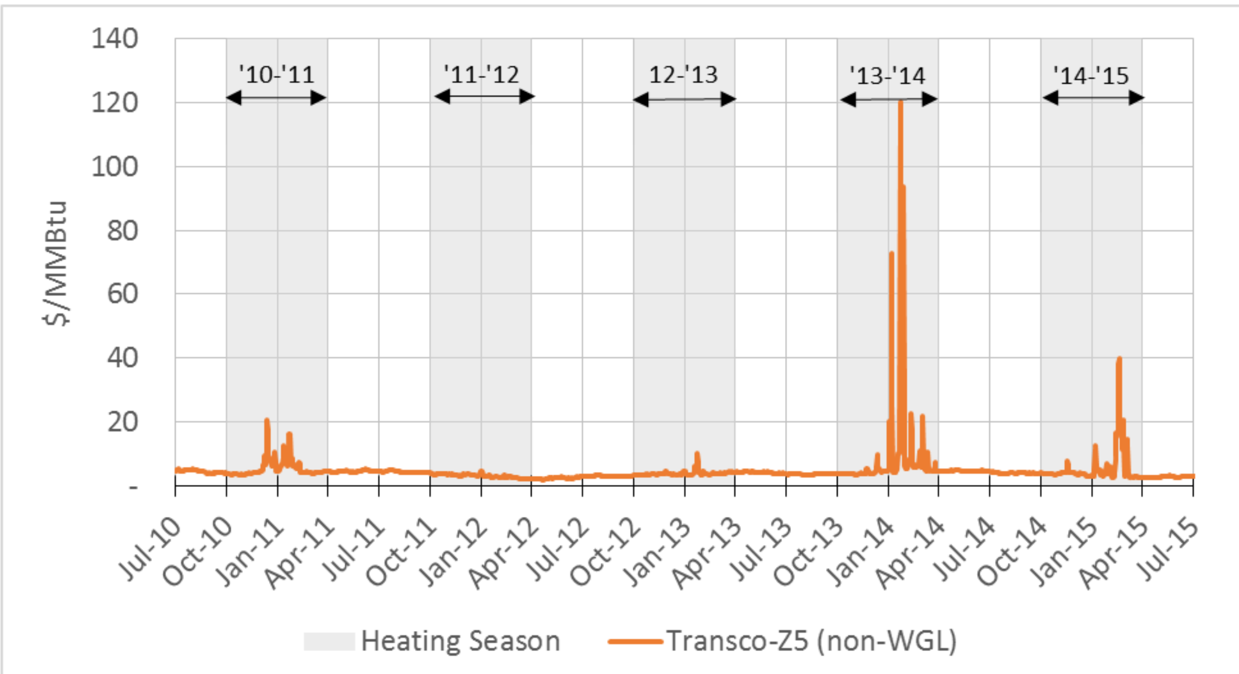
| | Transco Zone 5 | | Florida Gas Transmission Zone 3 | | TETCO M1 | | Henry Hub | |
|---|---|---|---|---|---|---|---|---|
| | Peak Day | Avg. | Peak Day | Avg. | Peak Day | Avg. | Peak Day | Avg. |
| **Average of Heating Season 2008-2009 through 2012-2013** | 10.81 | 4.75 | 5.60 | 4.15 | 5.55 | 4.13 | 5.53 | 4.10 |
| **Heating Season 2013-2014** | 120.21 | 8.48 | 8.01 | 4.46 | 8.84 | 4.43 | 7.92 | 4.44 |
| **Heating Season 2014-2015** | 39.90 | 5.32 | 4.47 | 3.32 | 4.35 | 3.23 | 4.41 | 3.31 |

Source: Ventyx.

For the winter of 2014-2015, Henry Hub average price and peak price were both lower than the five-year average, and much lower than the winter of 2013-2014. Other pricing points in the South, Tetco M1 in Mississippi and Florida Gas Transmission Zone 3 near Florida, exhibited similar behavior as Henry Hub, increasing during the winter of 2013-2014 and then decreasing for the 2014-2015 winter. This reflects that supply and pipeline capacity serving these markets are generally sufficient even under stressful demand conditions.

In contrast, gas prices farther up the East Coast were much higher and more volatile during both winters due to pipeline constraints. As shown in Figure 4-5, the daily spot price reached an unprecedented $120/MMBtu on January 22, 2014 at Transco Zone 5, a pricing point covering Virginia, North Carolina and South Carolina. Prices also stayed high throughout the winter of 2013-2014, with prices above $20/MMBtu for 13 days, as compared to only one day over $20/MMBtu in the previous five years combined. Since the Transco Zone 5 market area is served by pipelines that also serve the New England and Mid-Atlantic, pipeline capacity can be stressed if simultaneous cold weather conditions result in extreme load requirements along all pipeline segments, as demonstrated by the extreme prices seen during the winter of 2013-2014.

***Figure 4-5 Daily Natural Gas Prices ($/MMBtu) at Transco Z5: July 2010 – July 2015***



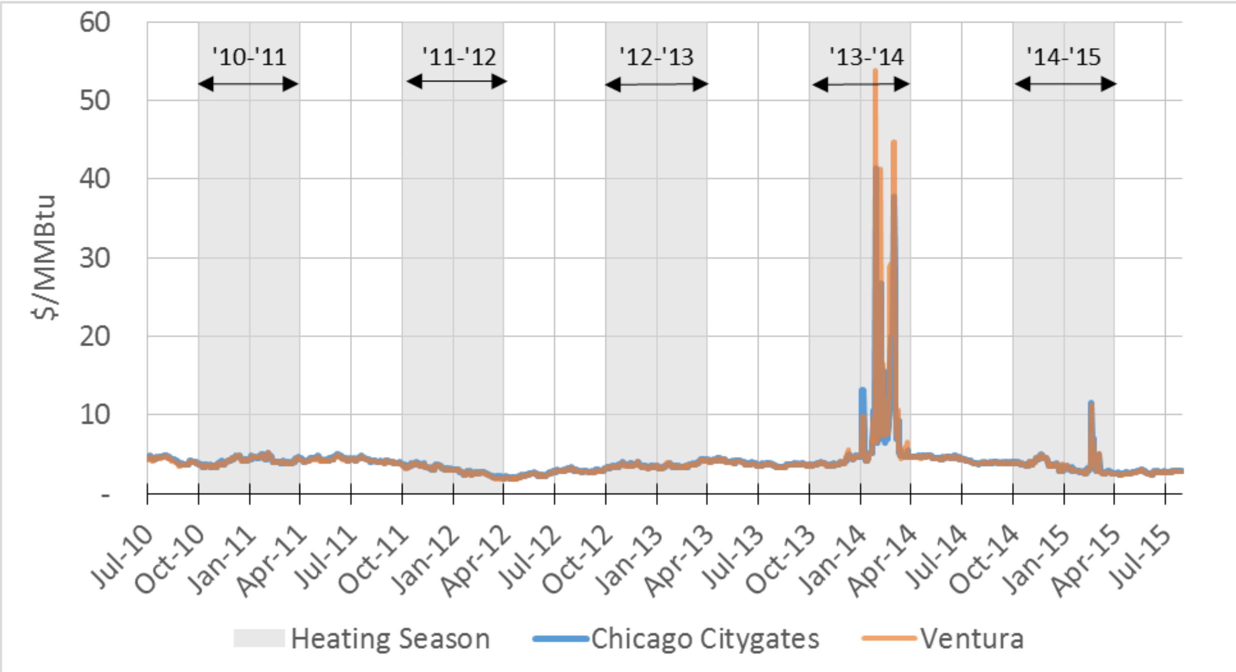

Source: Ventyx.

## Midwest (West North Central and East North Central)

Typically, natural gas spot prices in the Midwest have been lower and less volatile than those in market areas in the Northeast, due to ample storage capacity and access to multiple natural gas supply sources, including the Rockies, Mid-continent, Western Canada, and most recently the Marcellus Shale. Figure 4-6 and Table 4-3 show the region experienced price spikes during the past two winters, with Chicago price peaking above $41/MMBtu on January 27, 2014, and $11/MMBtu on February 18, 2015. As a comparison, the highest price reached in the previous five winters was $5.64/MMBtu.

Ventura reflects prices for natural gas delivered to Iowa and other West North Central markets. Closely correlated with the Chicago market, Ventura price reached peak prices on the same days as Chicago, nearly \$54/MMBtu and \$11/MMBtu respectively, for the 2013-2014 and 2014-2015 winters, indicative of the higher prices experienced throughout the Midwest.

*Figure 4-6 Daily Natural Gas Prices (\$/MMBtu) in East North Central and West North Central Regional Markets: July 2010 – July 2015*




Source: Ventyx.

*Table 4-3 Heating Season Natural Gas Prices in Midwest Markets, \$/MMBtu, Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average in Winters 2008-2009 to 2012-2013*

| | Ventura | | Chicago | |
|---|---|---|---|---|
| | Peak Day | Avg. | Peak Day | Avg. |
| **Average of Heating Season 2008-2009 through 2012-2013** | 5.60 | 4.16 | 5.64 | 4.21 |
| **Heating Season 2013-2014** | 53.91 | 7.43 | 41.31 | 6.79 |
| **Heating Season 2014-2015** | 11.31 | 3.57 | 11.58 | 3.60 |

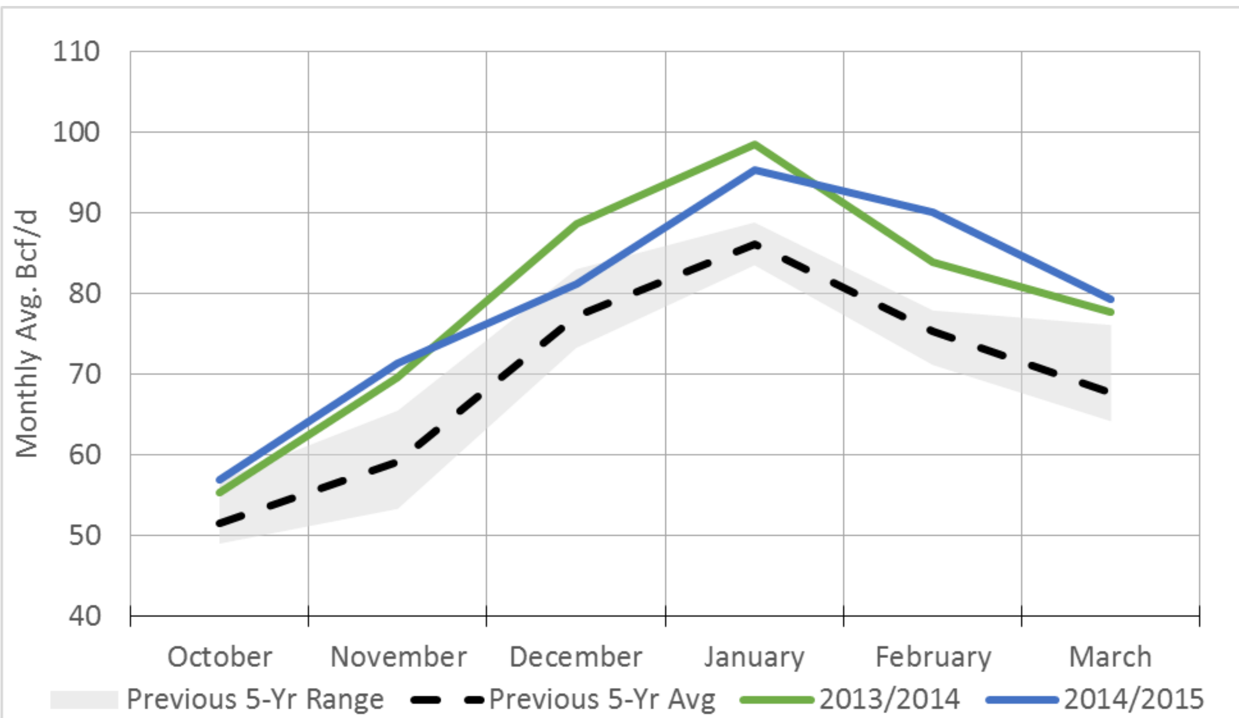
Source: Ventyx.

## Demand

As discussed in the introduction, weather is a principal driver of demand for natural gas.[59] Demand increases resulting from cold weather were a fundamental driver of prices during the winters of 2013-2014 and 2014-2015. The prices experienced in the 2013-2014 winter were extremely high and more volatile because there were several sustained cold stretches from December to March that caused simultaneous demand spikes along the East Coast and in the Midwest. The fact that December 2014 was milder than the previous December, and the Midwest was not as cold throughout the winter, contributed to less extreme prices in the winter of 2014-2015.

As shown in Figure 4-7, monthly natural gas deliveries to consumers[60] for both winters was significantly higher than the previous five-year average, and was mostly at or above the previous maximum levels. Consumption during the winter of 2013-2014 was higher than the previous five-year maximum every month of the season, with December and January exceeding the previous maximum by 15%. December and January consumption for the winter of 2014-2015, although still high, was below 2013-2014 levels.

*Figure 4-7 U.S. Lower-48 Total Monthly Average Natural Gas Consumption, Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in Winters 2008-2009 to 2012-2013*




Source: Energy Information Administration, Total Consumption: Volumes Delivered to Consumers, October 2010 – March 2015.

---

[59] Unlike fuel oil, natural gas customers do not store gas on site; it is consumed as soon as it is delivered. Therefore, the reported monthly volumes delivered to consumers are the same as the monthly demand.

[60] Data includes deliveries to residential, commercial, industrial, vehicle fuel and electric power consumers.

### Consumption by Sector

Natural gas is delivered to customers in four major sectors: residential, commercial, industrial, and power generation. For the United States in total, the residential and commercial sectors together account for 34 percent of annual consumption, while the industrial and power sectors account for 31 percent and 35 percent, respectively.[61] Residential and commercial customers primarily use natural gas for space heating, water heating, and cooking; industrial and power generators use it as a feedstock or fuel.

In most regions of the United States, cold winter weather directly results in significant increases in residential and commercial gas demand to heat houses and other buildings. The LDCs that serve residential and commercial customers contract for firm natural gas supplies (including natural gas pipeline transportation services and storage services) to meet their customers' projected maximum daily demand (referred to as the "design day" demand). Notwithstanding some isolated incidents, there were no major disruptions of residential and commercial gas service during either winter.[62]

When residential and commercial demands are below their design day values, the pipeline capacity contracted by the LDCs is available to other consumers (i.e., industrial consumers and power generators) that have not contracted for firm gas supplies. However, when winter weather is much colder than normal, residential and commercial demand increases, and less pipeline capacity is available to meet demand of non-firm consumers.

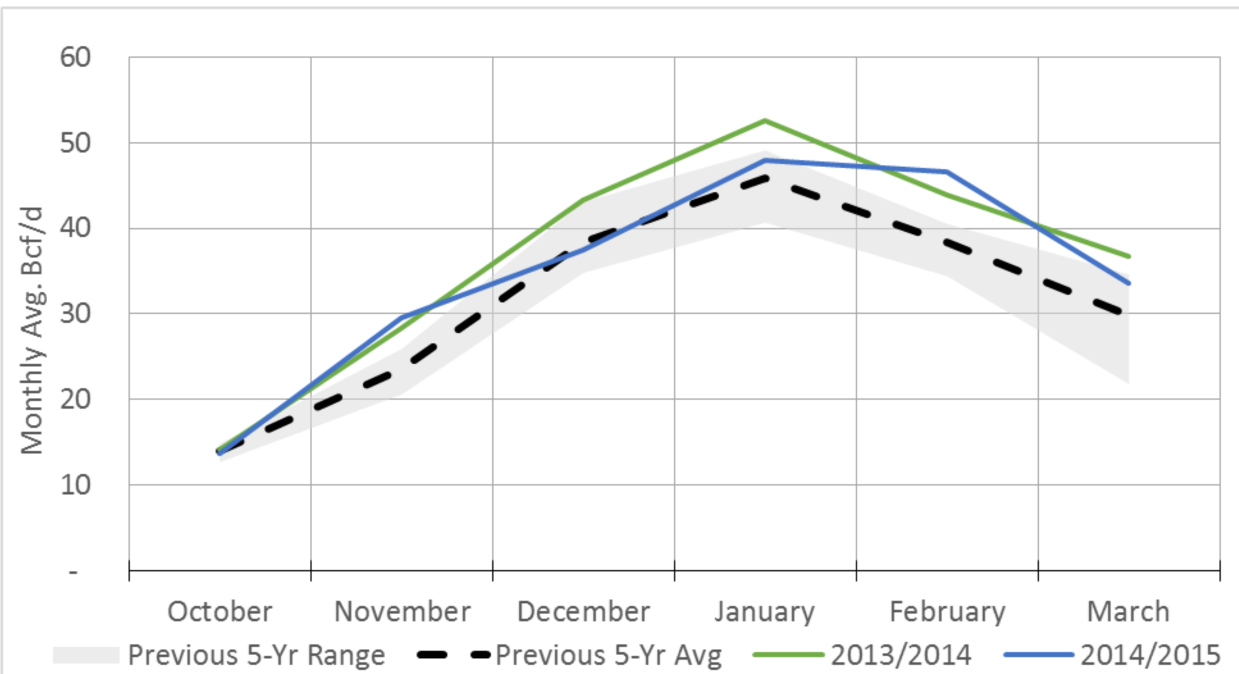
[61] Based on 5-year averages of U.S. Gas Consumption by End Use, as reported by the U.S. Energy Information Administration. http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm, accessed on August 31, 2015.

[62] The most significant natural gas system disruption that occurred over the winters of 2013-2014 and 2014-2015 was the January 25, 2014 explosion on TransCanada Pipeline's Emerson. The explosion resulted in a complete shutdown of the Emerson lateral, which severely limited gas supplies to Viking Gas Transmission, a U.S. pipeline that receives gas from the Emerson lateral at the Canada/Minnesota border. Viking was able to fully restore service on its system within two days after the event. The disruption was documented in information postings on both TransCanada's and Viking's web sites; see: http://www.transcanada.com/customerexpress/mainline.html and http://vgt.oneokpartners.com/en/Informational%20Postings.

As shown in Figure 4-8, higher demand levels during the winter of 2013-2014 contributed to sustained pipeline constraints and price spikes. While gas demand was above average for most of the winter of 2014-2015, it was not as high as during the prior winter, resulting in reduced pipeline constraints and (relatively) lower gas prices.

During the winter, gas consumption in the industrial and power sectors are less sensitive to weather and more price responsive. In the power sector, most natural gas generators in the Northeast operate in competitive electricity markets that do not have mechanisms for the recovery of costs associated with firm natural gas supply and transportation contracts;[63] as a result, most rely on the spot market to acquire fuel and transportation services. The LDCs that serve residential and commercial gas customers hold the majority of firm transportation contracts on the interstate pipeline network. When firm contract holders such as the LDCs utilize their maximum supply potential (for example, to meet high residential and commercial demand on a cold day), available non-firm supply for power generators becomes scarce and gas prices increase.

***Figure 4-8 U.S. Lower 48 Residential and Commercial Monthly Average Natural Gas Consumption, Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in Winters 2008-2009 to 2012-2013***

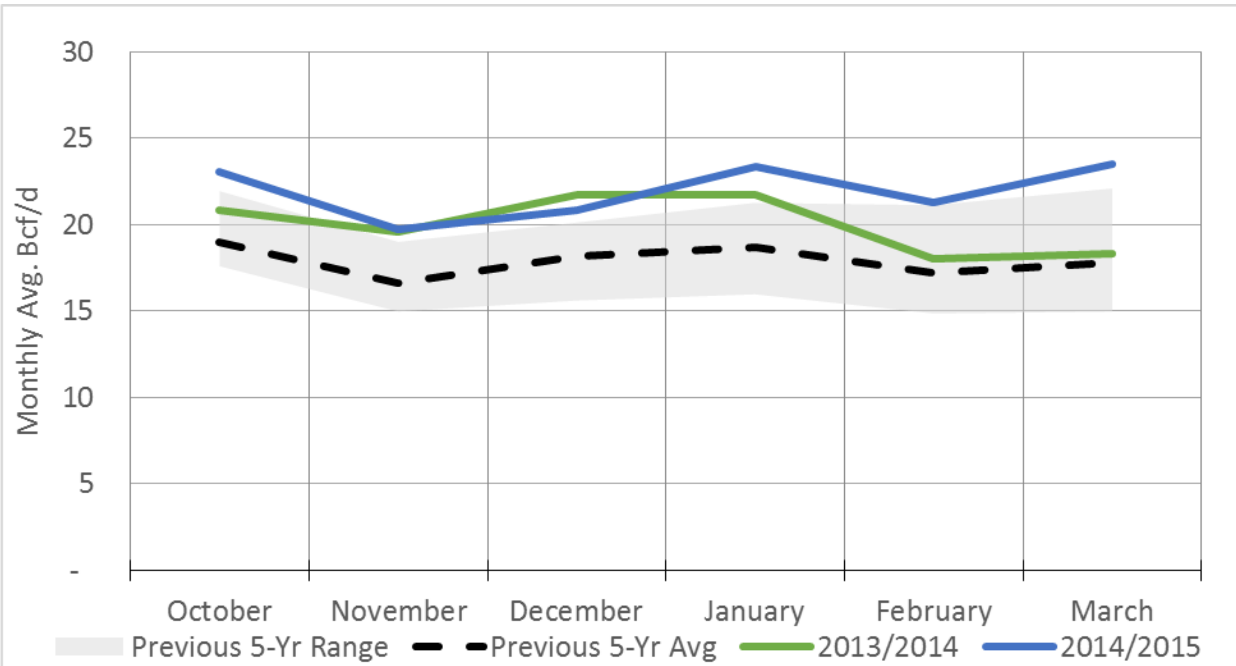



Source: Energy Information Administration, Total Consumption: Natural Gas Consumption by End Use, October 2010 – March 2015.

[63] Massachusetts Department of Energy, "Request to Open an Investigation into New, Incremental Natural Gas Delivery Capacity for Thermal Load and Electric Generation." April 2, 2015. http://web1.env.state.ma.us/DPU/FileRoomAPI/api/Attachments/Get/?path=15-37%2finitial_filing.pdf

During the winters of 2013-2014 and 2014-2015, power consumption was higher than average over the previous five years, as shown in Figure 4-9 below. Outages of coal units in PJM on the coldest days of the 2013-2014 winter contributed to the increase in gas demand and gas prices, as well as concerns about electric reliability (see discussion of equipment outages in Electricity Chapter). Initiatives taken by PJM and ISO-NE prior to the winter of 2014-2015 likely helped to moderate gas prices and price volatility that winter.

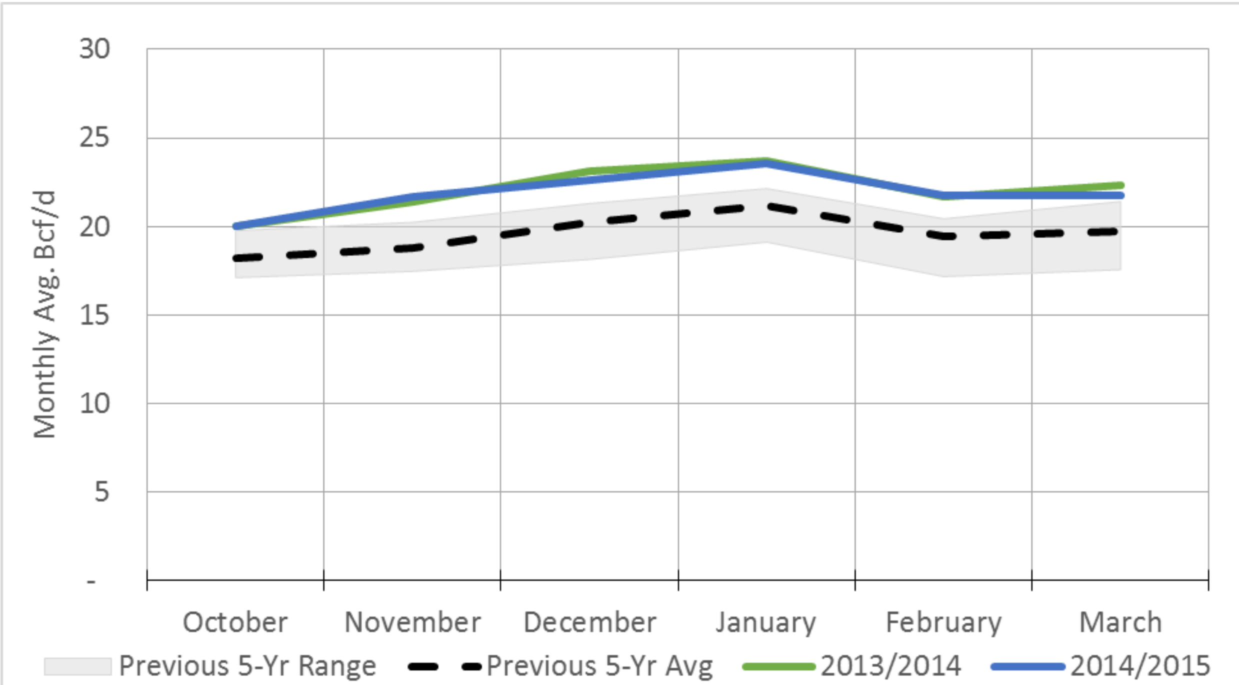
***Figure 4-9 Natural Gas Consumption for Electric Power Generation in the U.S. Lower 48, Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in Winters 2008-2009 to 2012-2013***




*Source: Energy Information Administration, Total Consumption: Natural Gas Consumption by End Use, October 2010 – March 2015.*

Industrial natural gas demand has been growing steadily over the past five years due to growth in domestic gas production and generally lower gas prices. Since 2009, industrial demand for natural gas has increased by 24%.[64] This steady growth led to fairly consistent levels of industrial gas demand during both winters, as shown in Figure 4-10.

***Figure 4-10 Natural Gas Consumption in the Industrial Sector in the U.S. Lower 48, Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013***




Source: Energy Information Administration, Total Consumption: Natural Gas Consumption by End Use, October 2010 – March 2015.

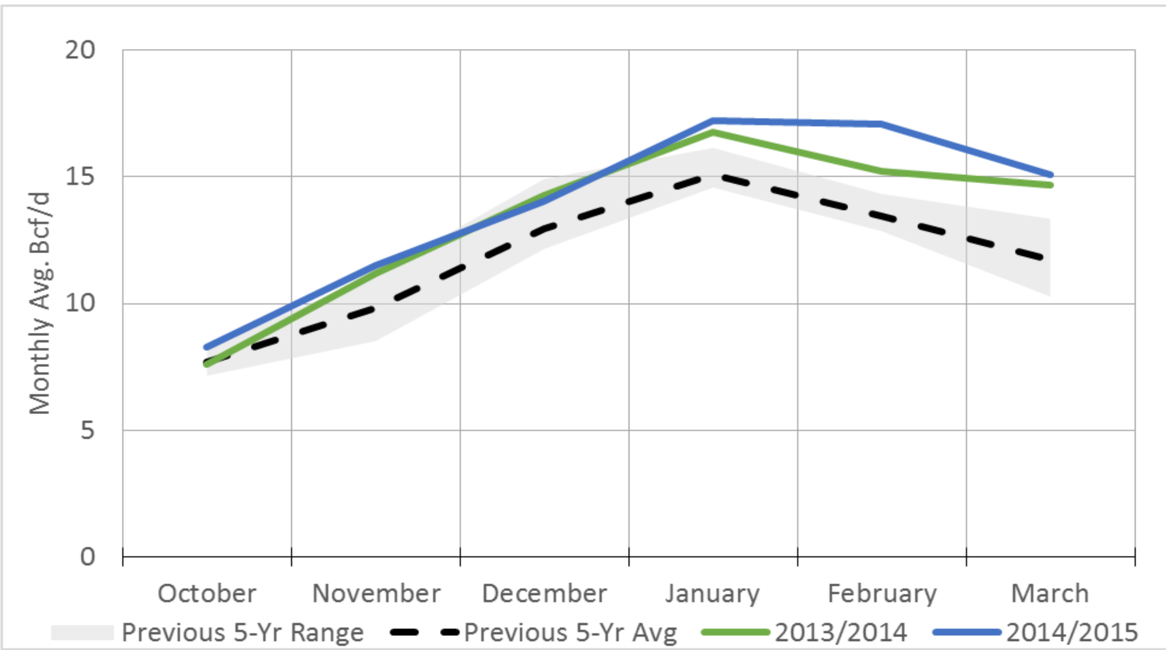
64 U.S. Energy Information Administration. "New methanol and fertilizer plants to increase already-growing industrial natural gas use." Today in Energy, July 29, 2015.

### Consumption by Census Region

As shown in Figure 4-11 through Figure 4-13, during the winters of 2013-2014 and 2014-2015, natural gas consumption in the Northeast, Midwest, and South regions were all higher than the previous five winters' average.

Figure 4-11 shows that for the Northeast (which includes New England and Mid-Atlantic regions), natural gas demand was at or above the previous five-year highs throughout most months during both winters.

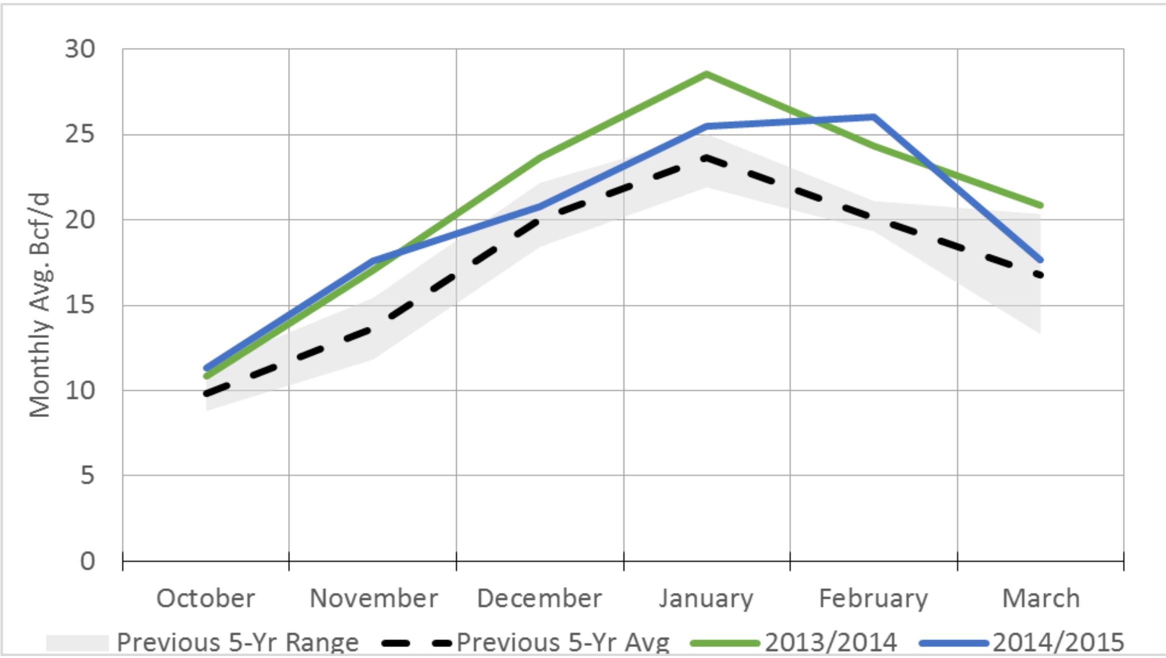
*Figure 4-11 New England and Mid-Atlantic Average Monthly Winter Demand for Natural Gas Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013*




Source: Energy Information Administration, Total Consumption: Volumes Delivered to Consumers, October 2010 – March 2015.

Figure 4-12 shows that demand in the Midwest (including East North Central and West North Central regions) in the 2013-2014 winter was higher than any of the previous five winters. While winter demand peaked in January during the winter of 2013-2014, the peak was later and not quite as high during the winter of 2014-2015.

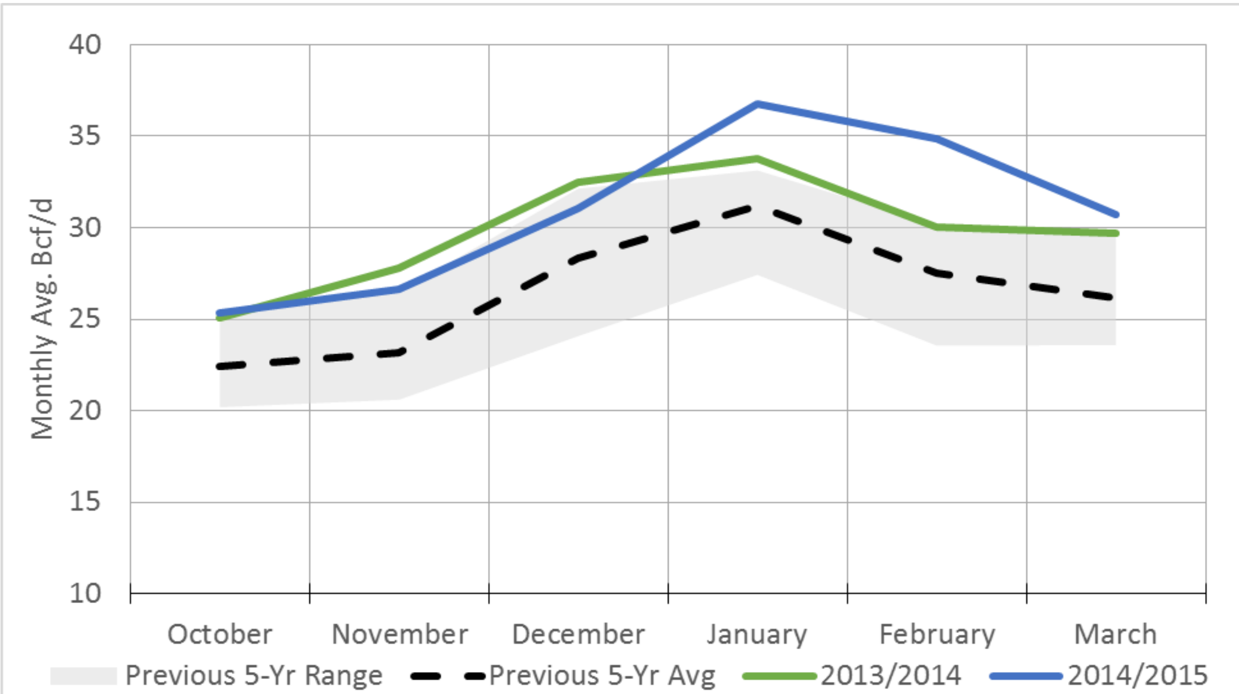
***Figure 4-12 East North Central and West North Central Average Monthly Winter Demand Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013***




Source: Energy Information Administration, Total Consumption: Volumes Delivered to Consumers, October 2010 – March 2015.

Figure 4-13 shows that demand in the South (including East South Central, West South Central, and South Atlantic regions) was relatively high during both winters. During the winter of 2013-2014, demand was higher earlier (in November and December), while 2014-2015 demand was higher later in winter (January, February, and March).

*Figure 4-13 East South Central, West South Central, & South Atlantic Average Monthly Winter Demand Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013*




Source: Energy Information Administration, Total Consumption: Volumes Delivered to Consumers, October 2010 – March 2015.

## Supply

U.S. natural gas supplies come primarily from domestic production, with pipeline imports from Canada providing additional supplies. Domestic gas production has been growing constantly since 2009, increasing by over 4% per year. The growth is primarily driven by increasing production from shale resources, led by the Marcellus Shale in the Appalachian Basin.[65] Natural gas storage withdrawals also provide a significant portion of the supplies in the winter months. While LNG imports comprise a relatively small portion of the U.S. gas market, they remain a critical part of New England's winter natural gas supplies.[66]

---

65 "Marcellus, Utica provide 85% of U.S. shale gas production growth since start of 2012." Today in Energy, U.S. Energy Information Administration, July 28, 2015.

66 "The Role of LNG in Northeast Natural Gas (and Energy) Markets." Northeast Gas Association, June 2015. http://www.northeastgas.org/about_lng.php.

Since few areas in the United States have direct access to natural gas production fields, the availability of pipeline capacity from production areas is a crucial element of gas supply for most U.S. markets. Regardless of how much natural gas is being produced, a constraint on pipeline capacity at any point between where the gas is produced and where it is consumed can result in limitations on the availability of gas supplies to the market.

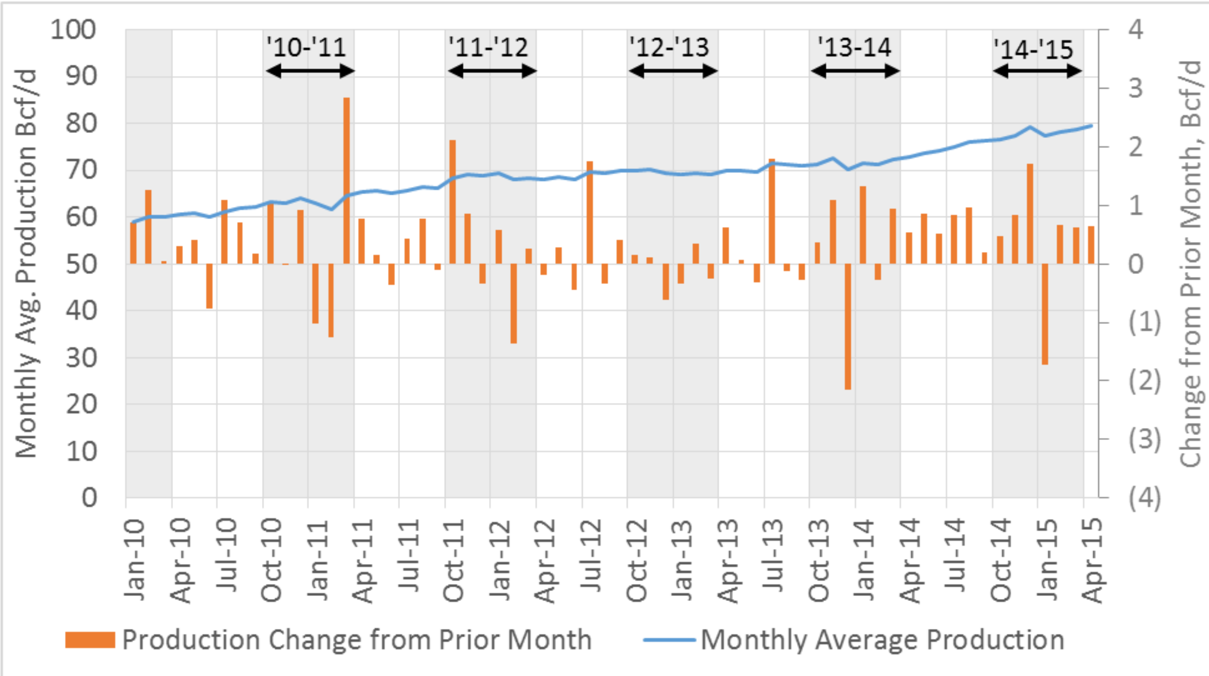
### Domestic Production

Annual domestic gas production has been steadily increasing, but the production trend during the winter of 2013-2014 was much less uniform. When ambient temperatures in a gas production field drop below freezing, production can be constrained by "wellhead freeze-offs," a phenomenon that occurs when water produced along with natural gas crystallizes inside the pipelines at or near the wells, blocking the flow of gas. While a number of freeze-offs occur during most winters, the widespread cold resulted in a significant increase in 2013-2014. This reduced U.S. gas production by an estimated 132 billion cubic feet (Bcf) over the course of the winter, equivalent to roughly two days of total U.S. production.[67]

The impact of freeze-offs on total U.S. monthly production volumes can be seen in Figure 4-14. In December 2013, production declined by 2.1 Bcf/d, a significantly larger monthly drop than was seen in any of the prior three winters. Total production recovered slightly in January 2014, but dropped again in February. During the winter of 2014-2015, a production increase in December 2014 of 1.7 Bcf/d was offset by an equal decline of 1.7 Bcf/d in January 2015, but production then increased steadily over the remaining months of winter.

[67] Platts Gas Daily. Monday, March 31, 2014, op. cit.

*Figure 4-14 U.S. Marketed Gas Production: January 2010 – April 2015*




Source: Energy Information Administration, Natural Gas Gross Withdrawals and Production: Marketed Production, January 2010 – April 2015.

## Pipeline Constraints

Regional pipeline constraints also contributed to the extreme market prices observed during the winter of 2013-2014. During some of the coldest days in winter 2013-2014, in order to prevent system imbalances and protect operational integrity, several pipelines issued operational flow orders (OFOs) that required shippers to balance their supplies with their customers' usage, and in some cases Emergency Flow Orders (EFOs) were issued to involuntarily divert supply from some customers. However, customers who held firm transportation rights on natural gas pipeline capacity in general were able to secure deliveries.[68]

For example, amid the heavy snowfall and frigid cold conditions from Washington DC to Boston during the week of January 20, 2014, Transcontinental Gas Pipe Line announced that due to high demand it had issued a system-wide OFO imbalance beginning on Tuesday (January 21).[69] Restrictions on interruptible capacity were near 100% at multiple points on Algonquin Gas Transmission's line, and restrictions were also seen on Texas Eastern Transmission and Dominion Transmission.[70] OFOs were also issued by several western pipelines in February

68 FERC, Winter 2013-2014 Operations and Market Performance in RTOs and ISOs. April 1, 2014 https://www.ferc.gov/legal/staff-reports/2014/04-01-14.pdf

69 Transcontinental Gas Pipe Line Company, LLC, Informational Postings web site, Critical Notices section, posted January 20, 2014 07:27:34 CST. http://www.1line.williams.com/Transco/index.html.

70 "Northeast cash tops $100, crushing records." Platts Gas Daily, January 22, 2014.

2014, when wellhead freeze-offs in the Rockies and Texas constrained gas supplies flowing into the pipeline network.[71]

According to the American Gas Association (AGA), during the winter of 2013-2014, 63% of companies surveyed reported upstream pipeline OFOs that impacted their system operations.[72] The median number of OFO notices was eight, while the average duration was slightly above 3.5 days. Based on these statistics, the average U.S. gas shipper was limited by an OFO for approximately 28 days during the winter of 2013-2014. However, OFOs can be declared for a wide range of reasons, such as freeze-offs, pressures reaching operational minimums or maximums, and maintenance issues, among numerous other reasons; thus, not all of these OFOs can be attributed to cold-induced high demand.

### Imports

U.S. natural gas imports from Canada have been decreasing since 2007, and rising shale gas production in the United States, especially in the Marcellus Shale, is a key factor in this trend. [73] As Marcellus Shale production has risen, the Northeast United States has become a net exporter to Canada during warm months. The extreme cold weather also contributed to the reduction in U.S. imports during the winters of 2013-2014 and 2014-2015. The same cold weather that was affecting the United States was also affecting Canada, causing Canada's consumption to rise and thereby reducing supplies available for export.[74] During the winters of 2013-2014 and 2014-2015, net imports from Canada to the U.S. Northeast and Midwest were 5.5 Bcf/d and 5.6 Bcf/d, respectively (Figure 4-15), about 13 percent below the 5-year average.

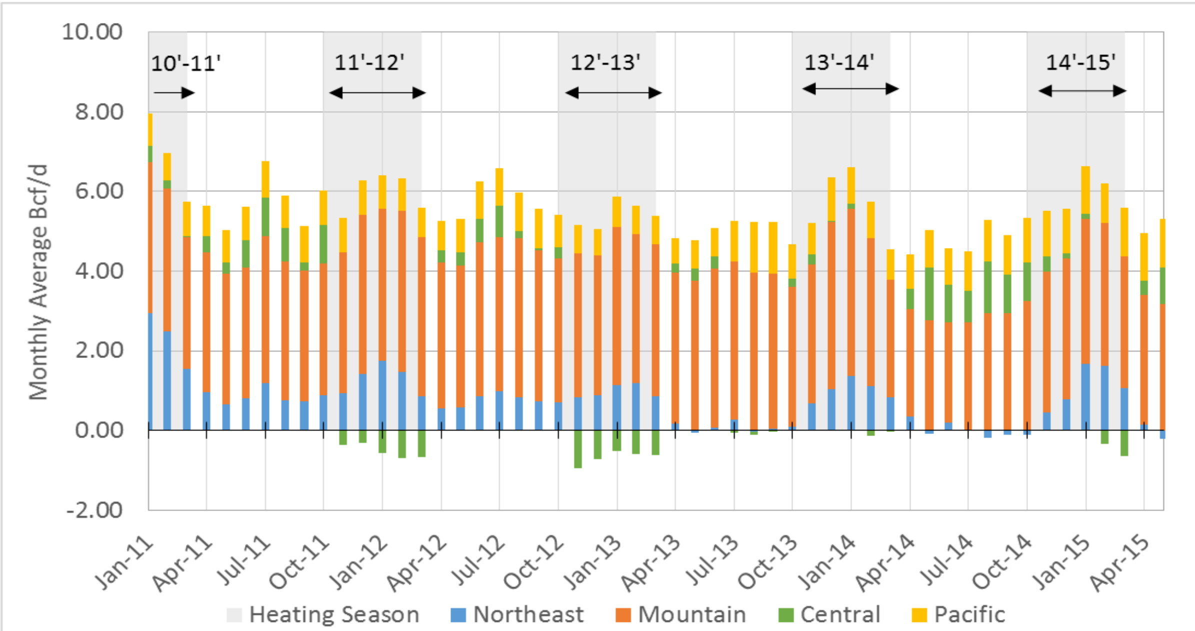
[71] "Gas Events and Market Results of February 6, 2014," California ISO Technical Bulletin, May 2014.

[72] "Promise Delivered - Planning, Preparation and Performance during the Winter Heating Season". AGA, September 2014.

[73] "Canada Week: Natural gas net imports from Canada continue to decline." Today in Energy, U.S. Energy Information Administration, November 30, 2012. http://www.eia.gov/todayinenergy/detail.cfm?id=8990.

[74] "Short-term Canadian Natural Gas Deliverability, 2014-2016." National Energy Board, May 2014. https://www.neb-one.gc.ca/nrg/sttstc/ntrlgs/rprt/ntrlgsdlvrblty20142016/ntrlgsdlvrblty20142016-eng.html.

*Figure 4-15 Total U.S. Canadian Pipeline Natural Gas Imports by Region of Entry: January 2011 – April 2015*



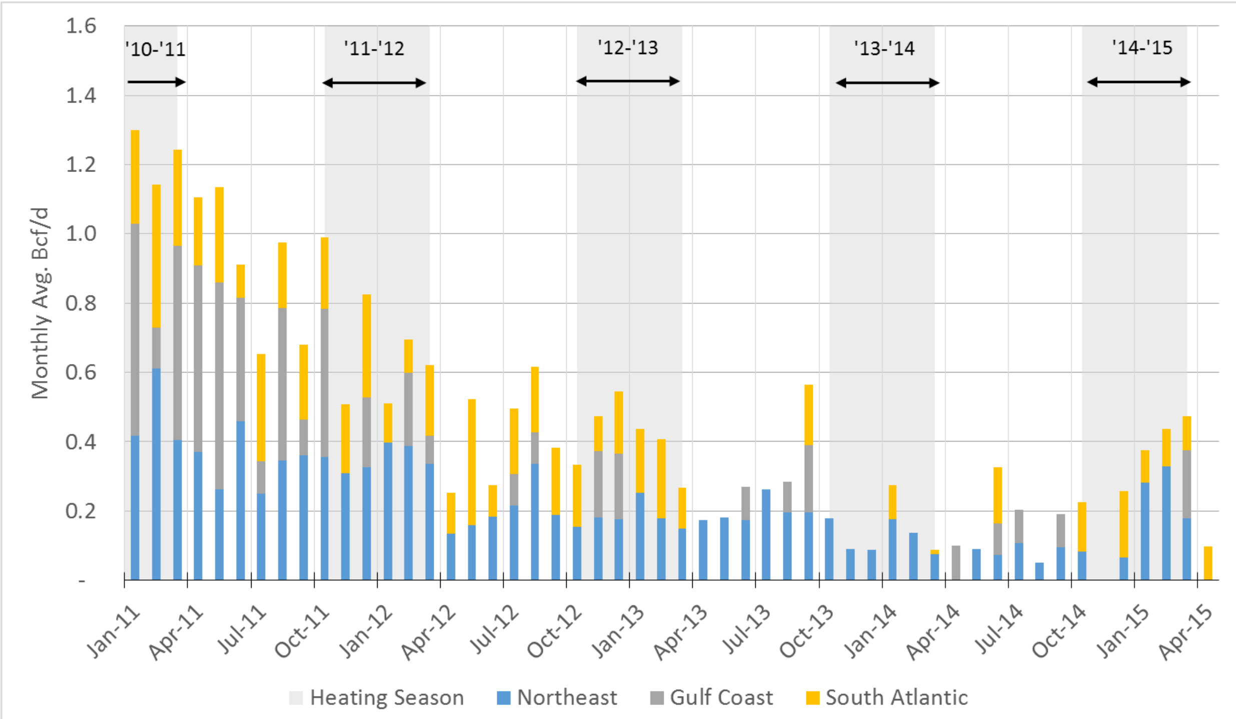

Source: Energy Information Administration, U.S. Natural Gas Pipeline Imports by Point of Entry, January 2011- April 2015.

Note: The EIA reports data prior to January 2011 in a different format; therefore, it has been excluded for consistency.

In the years leading up to the winter of 2013-2014, the decline in domestic natural gas prices led U.S. LNG importers to forgo renewing long-term contracts for LNG supplies. As a result, between 2010 and 2012, LNG imports declined by nearly 60%, as shown in Figure 4-16. Following the high prices experienced during the winter of 2013-2014, LNG imports into the Northeast increased in the winter of 2014-2015 due to expectations of strong regional prices and lower global LNG prices. For example, Excelerate Energy's Northeast Gateway offshore LNG terminal received its first shipments in five years, delivering a total of 2.6 Bcf into the Boston area in January and February 2015.[75] This helped the Northeast region avoid the extreme price increases experienced in the previous winter amid similarly cold weather conditions.

[75] "Deliveries of liquefied natural gas take edge off region's supply gap." Portland Press Herald, February 2, 2015. http://www.pressherald.com/2015/02/01/deliveries-of-liquefied-natural-gas-take-edge-off-regions-supply-gap/.

*Figure 4-16 U.S. LNG Imports: January 2011 – April 2015*



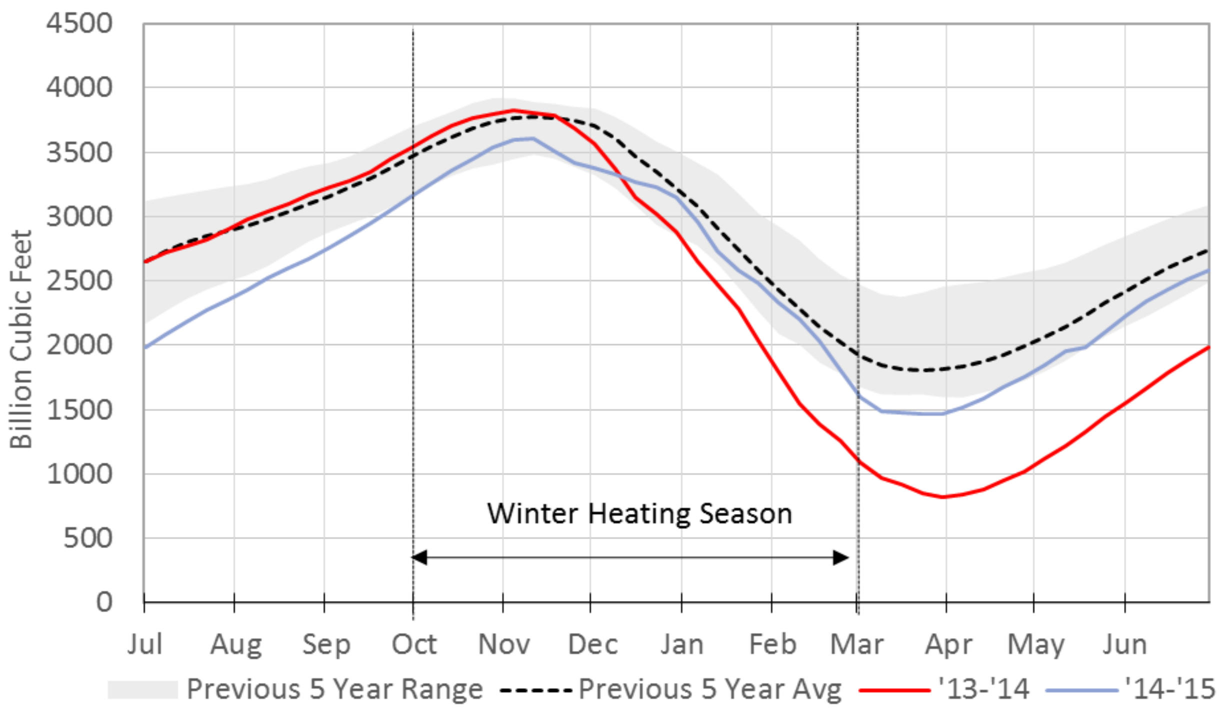

Source: Energy Information Administration, *U.S. Liquefied Natural Gas Imports by Point of Entry*, January 2011- April 2015.

Note: The EIA reports data prior to January 2011 in a different format; therefore, it has been excluded for consistency. Data for November 2014 was not reported.

## Storage Withdrawals

Natural gas storage inventories play a key role in supplying heating markets during the winter. Figure 4-17 shows that the winter of 2013-2014 started off with storage inventories for the lower 48 states slightly above average. However, as winter progressed, storage inventories fell to more than 50% below five-year average levels. EIA's weekly reports on natural gas storage inventories are closely monitored by spot market participants, and below-average storage inventories are typically seen as a "bullish" signal for natural gas prices. During the winter of 2014-2015, U.S. storage inventory levels fell to 20% below average in March 2015, but did not fall as far as in 2013-2014.

*Figure 4-17 U.S. Lower 48 Natural Gas Underground Storage Levels*



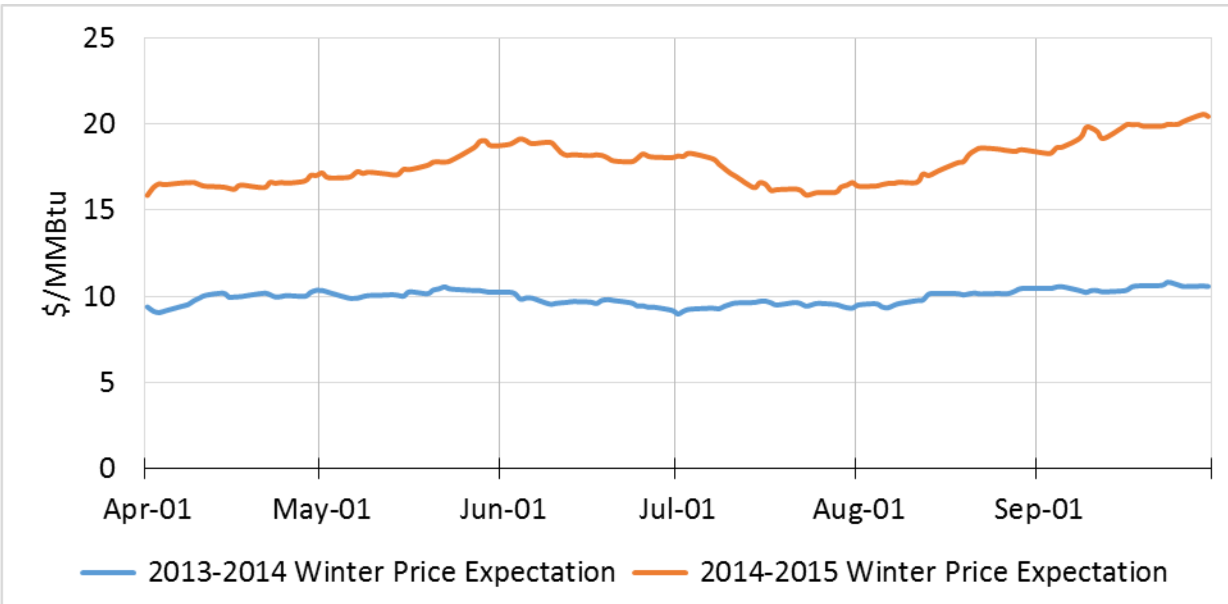

Source: Energy Information Administration, *Weekly Working Gas in Underground Storage,* July 2008- May 2015.

## Market Preparedness

In addition to the actual supply readiness and resource availability, it is likely that market expectations entering the winters of 2013-2014 and 2014-2015 were drastically different than in prior years. Prior to the winter of 2013-2014, the United States had not seen a significantly colder-than-normal winter for more than 10 years, and had recently experienced the warmest winter on record (the winter of 2011-2012). After the price shocks of the 2013-2014 winter, market participants recognized that the potential existed for high and volatile natural gas prices, and preemptive measures were taken prior to the winter of 2014-2015 that were likely to have helped moderate average prices and dampen daily price volatility.

Forward market gas contract prices are an indicator of the market's expectations prior to any given winter season. As shown in Figure 4-18, for the five months prior to the winter of 2013-2014 the market was expecting Algonquin Citygates (Boston, MA) prices to average around $10/MMBtu for the peak winter months (December, January and February). After experiencing the high and volatile prices during the winter of 2013-2014, the expectation for the next winter's (2014-2015) prices rose dramatically. By the end of September 2014, the expectation for the Algonquin winter price reached $20/MMBtu. End users and potential suppliers were motivated by the expectations of high price to take measures in advance to reduce demand and/or increase supply for the winter of 2014-2015. For example, ISO New England expanded its Winter Reliability Program[76] (which incentivizes electricity generators to have alternate fuels available) to include LNG, prompting an increase in LNG imports, as shown above in Figure 4-16.

*Figure 4-18 Algonquin Citygates Forward Price Expectations, Winter 2013-2014 vs. Winter 2014-2015*




Source: SNL, NYMEX Henry Hub Futures and Algonquin Citygates Forward Basis Swaps from April 1 2013 – September 30 2013 (for Winter 2013-2014), and April 1 2014 – September 30 2014 (for Winter 2014-2015).

[76] FERC Order Accepting Tariff Revisions, Docket Nos. ER14-2407-000-002, op. cit.

*This page intentionally blank*

# 5. Electric Power Markets

## Summary

The weather conditions during the winters of 2013-2014 and 2014-2015 had particularly adverse effects on power markets in the Northeast (New York, New England and Mid-Atlantic) and the Midwestern United States. The periods of extreme cold led to abnormally high electricity demand for concentrated periods of time. While virtually no load was lost in the Eastern Interconnect during these two winters, meeting this level of power demand was a challenge for the industry.[77]

During the aforementioned winters, natural gas supply into the Northeast region (especially New England, which is heavily dependent on natural gas for electricity generation) was already constrained by weather-induced high demand for space heating and limited pipeline capacity.[78] The significant loss of electric generation capacity that followed was due, in part, to lack of access to fuel.[79] The ability of some generating units to switch to petroleum as a fuel source preserved some of this capacity; however, it increased demand for distillate and other fuel oils, contributing to price increases for electricity.[80] Further, the cold temperatures put severe strains on generator equipment and considerable capacity was lost due to malfunctioning equipment and other operating problems during the extreme weather events of the winter of 2013-2014.[81] Some of the power generator outages were the result of fuel constraints, but many were attributed to the inability of some units to operate at temperatures below their design standards.[82] Overall, the extreme cold and winter storms in the winter of 2013-2014 challenged the reliability of the electric generating system simply because many operators were unprepared for the extreme weather.

In the winter of 2014-2015, high demand and limited gas pipeline capacity into the Northeast were also concerns; however, supply problems were not as severe due to increased liquefied

---

77 According to the North American Electric Reliability Corporation (NERC), the amount of load shed was less than 300 MW during winter 2013-2014, representing less than 0.1% of the total load for the Eastern and ERCOT Interconnections. See Polar Vortex Review, September 2014. Accessed on August 1, 2015. http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf.

78 FERC, Ensuring Grid Reliability and Resiliency in New England. June 2014. Accessed August 25, 2015: http://www.ferc.gov/CalendarFiles/20140610083119-Brandien,%20ISO%20New%20England.pdf.

79 NERC, November 2014, Accessed August 2015: http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2014WRA_final.pdf.

80 EIA, Survey Form 923 data, Accessed July 2014.

81 NERC, Polar Vortex Review, Sept 2014. Accessed August 2015: http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf.

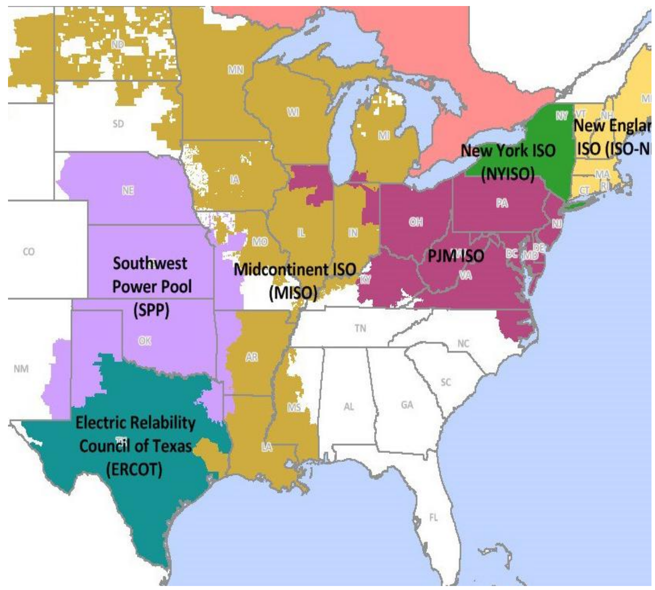
82 NERC, Polar Vortex Review, Sept 2014. Accessed August 2015: http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf.

natural gas (LNG) imports into the region, a decrease in global oil prices, and continuation of fuel reliability programs. This resulted in fewer severe price spikes during the winter of 2014-2015. Forced outages from natural gas interruptions decreased as well, especially in the Mid-Atlantic Region.[83]

This chapter provides an analysis of these occurrences, including the impacts of winter weather conditions on prices, consumption, supply, and the electric power sector's operations. Much of the data presented are based on Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs). See box below. The focus of this chapter is on ISO-NE, NYISO, MISO, and PJM regions, as most of the impacts of the winter weather on the electric system occurred in these areas.

**Regional Transmission Organizations and Independent System Operators** (sometimes called Reliability Coordinators) serve as third-party independent operators of the bulk power system. In the New England region (Maine, Vermont, New Hampshire, Massachuetts, Connecticut, and Rhode Island), the operator is ISO-New England (ISO-NE); for New York State, it is New York ISO (NYISO). In the Mid-Atlantic region, it is PJM (serving all or parts of Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, West Virginia and the District of Columbia). In the mid-west, the operator is the Mid-continent Independent System Operator (MISO).

Image source: http//www.ferc.gov/market-oversight/mkt-electric/overview/elec-ovr-rto-map.pdf. RTOs/ISOs reflected as of September 2015.




## Prices

In winter 2013-2014, wholesale electricity prices in the New England, New York, and Mid-Atlantic regions rose drastically in response to the extreme cold. Table 5-1 shows electricity prices for selected hubs in ISO-NE, NYISO, PJM and MISO during the months of January and February of the two winters, as well as the average prices over the same months in the preceding five years.

83 PJM Winter Report 2015, May 13, 2015. Accessed August 1, 2015.
http://www.pjm.com/~/media/documents/reports/20150513-2015-winter-report.

*Table 5-1 Real Time On-Peak Electricity Price ($/MWh) in ISO-NE, NYISO, PJM, and MISO in January and February, 2014 and 2015 vs. Prior 5-year Average in Winters 2008-2009 to 2012-2013*

| | Jan 5-Year Average | Jan 2014 | Jan 2015 | Feb 5-Year Average | Feb 2014 | Feb 2015 |
|---|---|---|---|---|---|---|
| **ISO-NE (Mass Hub)** | $69 | $188 | $72 | $65 | $179 | $134 |
| **NYISO (Zone J, NYC)** | $82 | $203 | $62 | $62 | $148 | $127 |
| **PJM (Western Hub)** | $51 | $161 | $44 | $44 | $81 | $80 |
| **MISO (Indiana Hub)** | $35 | $69 | $34 | $33 | $66 | $45 |

The prices indicated for January 2009-2013 and February 2009-2013 represent the average on-peak prices for the respective month over the five-year period. These are the months of January and February during the winters of 2008-2009 to 2012-2013. Source: SNL Financial: https://www.snl.com/SNLWebPlatform/Content/Commodities/EnergyMarkets/EnergyMarketsCommodityPrices.

In January 2014, real time on-peak prices[84] for the ISO-NE (Mass Hub), the NYISO (Zone J, NYC), and the PJM (Western Hub) were approximately two-to-three times the average level for the prior five-year period. For example, ISO-NE peak prices reached $188/MWh in January 2014, nearly three times the average level for the previous five-year period. Prices remained high in February relative to historic prices; however, prices moderated relative to January levels. In MISO, the price levels in January were slightly less dramatic relative to the five-year average. During the winter of 2014-2015, wholesale electricity prices were once again high, but less so than in 2013-2014. The highest 2015 prices were recorded in February, later in the season than average, and prices were generally double (or less than double) the prior five-year average.

Wholesale electricity prices are highly correlated to the price of fuel used by marginal generating units.[85] In many regions, including the ISO-NE, NYISO and PJM regions, natural gas plants are the marginal source of electricity, and thus wholesale electricity prices are closely tied to natural gas prices.[86] Figures 5-1 and 5-2 show natural gas prices and electricity prices during the July 2012 through June 2015 period in ISO-NE and PJM, respectively.

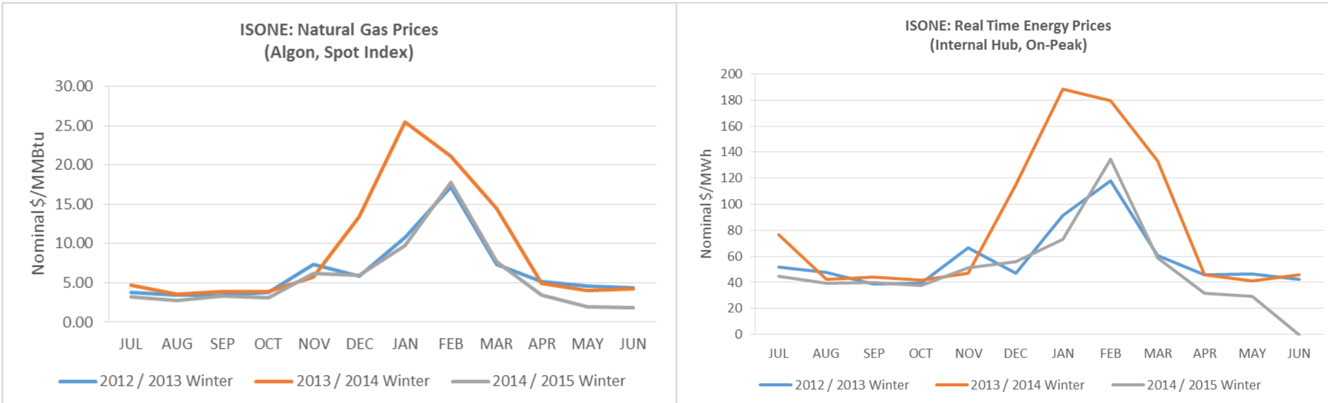
---

[84] SNL Financial. Accessed July 15, 2015. https://www.snl.com/SNLWebPlatform/Content/Commodities/EnergyMarkets/EnergyMarketsCommodityPrices.

[85] Marginal generating units are those that are the last to be brought on-line in a given time period, and they set the price for electric energy for that time period.

[86] Wholesale power market prices track power plant fuel prices. As natural gas is the marginal generating resource in New England, wholesale electricity prices track the price of natural gas. http://www.iso-ne.com/static-assets/documents/2015/02/2015-powergridprofile-final.pdf and http://www.eia.gov/electricity/monthly/update/wholesale_markets.cfm.

*Figure 5-1 Monthly Natural Gas Prices ($/MMBtu) and Electricity Prices ($/MWh) in ISO-NE: July 2012 – June 2015*




Source: SNL Financial.

In the Northeast Census region[87] more than 50%[88,89] of homeowners have gas-fired heating systems.[90,91] During the winter months, the demand for natural gas for home heating rises; consequently, the demand for pipeline capacity to deliver the natural gas for home heating rises. This leaves less natural gas pipeline capacity available to be utilized by generators (for reasons that are discussed in more detail in Chapter 4). These pipeline capacity constraint issues were particularly exacerbated during the extreme weather events of the winters of 2013-2014 and 2014-2015, and led to upward pressure on natural gas prices, driving wholesale electricity prices up as well. This is demonstrated in Figures 5-1 and 5-2 which show that electricity prices closely tracked natural gas prices, with both rising substantially during the winter seasons of 2013-2014 and 2014-2015.

87 The Northeast includes the six New England states of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut, and the three Mid-Atlantic region states of New York, Pennsylvania, and New Jersey.

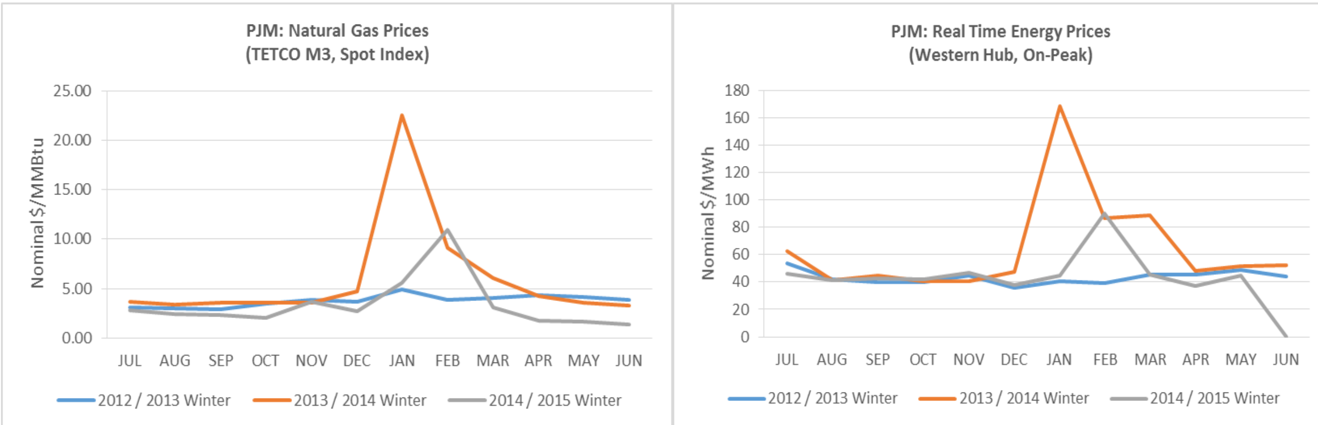
88 Table HC6.7, Space Heating in U.S. Homes, by Census Region, 2009, Residential Energy Consumption Survey.

89 "Everywhere but Northeast, fewer homes choose natural gas as heating fuel." September 25, 2014. Accessed August 2, 2015 http://www.eia.gov/todayinenergy/detail.cfm?id=18131.

90 In ISO-NE, 66% of the generating capacity is natural-gas fired and 4.5% is dual-fuel fired. In 2014, 39% of generation requirements were met with natural gas. ISO-NE Resource Mix. Accessed on August 1, 2015. http://www.iso-ne.com/about/what-we-do/key-stats/resource-mix.

91 ISO New England. Accessed July 15, 2015. http://www.iso-ne.com.

*Figure 5-2 Monthly Natural Gas ($/MMBtu) and Electricity Prices ($/MWh) in PJM, July 2012-June 2015*




Source: SNL Financial.

## Demand

When temperatures dropped to near record lows in January 2014, electricity consumption, as measured in kilowatt hour (kWh) sales, increased. Table 5-2 summarizes the sales levels during the coldest months of the two winter seasons as compared to the prior five year average for those same months for the five Census regions that map to the ISO/RTOs examined in this chapter. Sales to all customers in the coldest months of the two winters, January 2014 and February 2015, rose by varying amounts. In January 2014, sales increased 2.1% to 5.1% over the five-year historical average for those same months, by region. In February 2015, sales increased between 1.6% and 8.0% compared to the five-year historical average during the same months across the regions.

While total energy sales in (kWh) of electricity increased as a result of the weather in the two winters, as indicated above, they were not dramatically higher than the historical five year average. The significant challenge for the electric power sector was its ability to meet peak winter demand (MW). Figure 5-3 shows the monthly peak demands (MW) in PJM during the two winters as compared to average peak demand over the prior 5 years. On January 7, 2014, PJM set an all-time winter peak demand of 140,510 MW.[92] This figure was only 3.5% higher than its prior all-time record, but 20 % higher than the average of the prior five years. In 2015, PJM set yet another new winter peak demand record of 143,086 MW on the morning of February 20, 2015.[93] This level was 22% higher than the five year historical average. While summer peak demands in New England (and in most regions of the country) are often higher than winter peak demand levels, winter peaks in the Northeast are an issue because natural gas supply and delivery are constrained by space heating demands that do not exist in summer. Impacts of natural gas deliverability issues are discussed later in this chapter.

---

[92] See Polar Vortex Review, September 2014, NERC. Table 2. Accessed August 1, 2015. http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf.

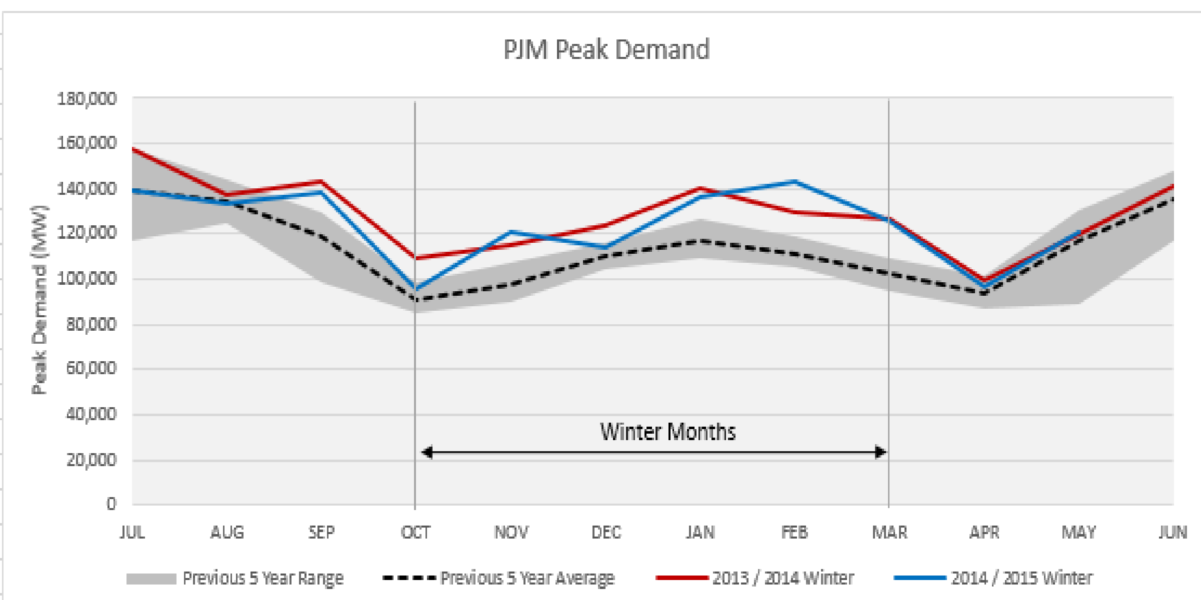
[93] 2015 Winter Report, PJM Interconnections. May 13, 2015. Accessed August 1, 2015. http://www.pjm.com/~/media/documents/reports/20150513-2015-winter-report.ashx.

*Table 5-2 Total Electricity Sales by Census Region in January and February, 2014 and 2015 vs. Prior 5-year Average in Winters 2008-2009 to 2012-2013 (MWhs and % Change)*

| Census Region (Overlapping ISO/RTO) | January 5-Year Sales (Average) | Jan 2014 Sales (% Δ Over Jan. 5-Yr Average) | Jan 2015 Sales (% Δ Over Jan. 5-Yr Average) | February 5- Year Sales (Average) | Feb 2014 Sales (% Δ Over Feb. 5-Yr Average) | Feb 2015 Sales (% Δ Over Feb. 5-Yr Average) |
|---|---|---|---|---|---|---|
| **New England (ISO-NE)** | 10.9 | 11.1 (2.1%) | 10.8 (-0.9%) | 10.0 | 10.4 (3.0%) | 10.5 (4.3%) |
| **New York (NYISO)** | 12.4 | 12.9 (4.5%) | 12.7 (2.2%) | 11.6 | 12.6 (8.6%) | 12.5 (7.5%) |
| **East North Central (MISO)** | 51.0 | 53.1 (4.3%) | 50.9 (-0.1%) | 45.7 | 47.8 (4.5%) | 47.7 (4.4%) |
| **East South Central (MISO)** | 29.2 | 29.9 (2.5%) | 28.2 (-3.6%) | 26.8 | 27.7 (3.6%) | 27.2 (1.6%) |
| **South Atlantic (PJM)** | 70.6 | 74.2 (5.1%) | 70.8 (0.2%) | 62.5 | 64.9 (3.8%) | 67.5 (8.0%) |

These are the months of January and February during the winters of 2008-2009 to 2012-2013. Source: SNL Financial: Source: U.S. Energy Information Administration, Form EIA-826, Monthly Electric Sales and Revenue Report with State Distributions Report as reported in the *Monthly Energy Review, April 2015.*

*Figure 5-3 Monthly Peak Winter Demands (MW) in PJM in Winters 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013*




Source: PJM.

The coincidence of peak loads[94] over a broad area was also a challenge for the electric power sector, particularly in winter 2013-2014. It was difficult for many systems to meet their own regional load, much less retain the flexibility to help neighboring systems experiencing peak loads at the same time. Table 5-3 summarizes the peak loads experienced across large portions of the Eastern Interconnect during the three-day period January 6-8, 2014. Shown are the absolute demand levels (in MW) as well as that load level as a percent of the prior historic peak demand for the region. PJM exceeded its historic winter peak twice on January 7 (morning and evening). MISO exceeded their historic winter peak for three straight days (January 6–8, 2014). In addition, several other Reliability Coordinators in the Eastern Interconnect experienced new peak winter loads or loads that were close to the previous all-time winter peak during the winter 2013-2014. Five other reliability coordinators set new all-time peaks on either January 6 or 7, 2014.[95]

*Table 5-3 Peak Demand (MW) During Winter 2013-2014 and as a Percent of Historic Peak Demands*

| Date | MISO | PJM | NYISO | ISO-NE |
|---|---|---|---|---|
| **Jan. 6 2014** | **109,307 (109.5%)** | 131,142 (95.5%) | 23,197 (90.8%) | 18,500 (81.1%) |
| **Jan. 7 2014** | 104,746 (104.9%) | **140,510 (103.5%)[a]** | **25,738 (100.8%)** | 21,300 (93.3%) |
| **Jan. 8 2014** | 100,154 (100.3%) | 133,288 (98.1%) | 24,551 (96.1%) | 20,800 (91.2%) |

**Bold text indicate all-time record winter peak demand.**

**[a]On this day, PJM also experienced a morning peak that exceeded the historic average.**

This table summarizes the peak loads (MW) experienced in MISO, PJM, NYISO, and ISO-NE during the three-day period January 6-8, 2014. Shown are the absolute demands (in MW) as well as that load level as a percent of the prior historic winter peak demand for the region. Source: Polar Vortex Review, September 2014, NERC. Accessed on August 1, 2015: http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf.

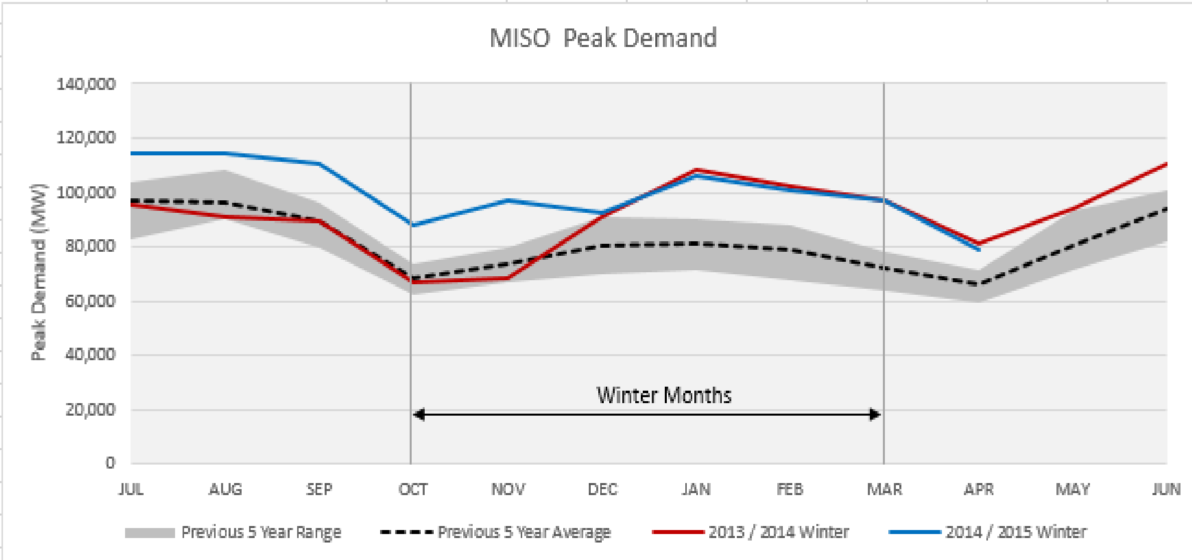
Figure 5-4 shows the winter peak demand in MISO over the two winters and the previous 5-year average. Winter peak demand in MISO was noticeably higher than in previous years (roughly 32% higher in both winters 2013-2014 and 2014-2015 relative to the five year historical average). As shown in Figure 5-4, peak demand jumped significantly from November 2013 to January 2014, in part due to severe weather events in early January. Peak levels in January 2015 in MISO were higher in the early part of the winter, reaching about the same level of demand as the prior year.

---

[94] Coincidental peak load is the sum of two or more peak loads that occur in the same time interval across one or more systems.

[95] Polar Vortex Review, September 2014, NERC. Table 2. Accessed August 1, 2015. http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf.

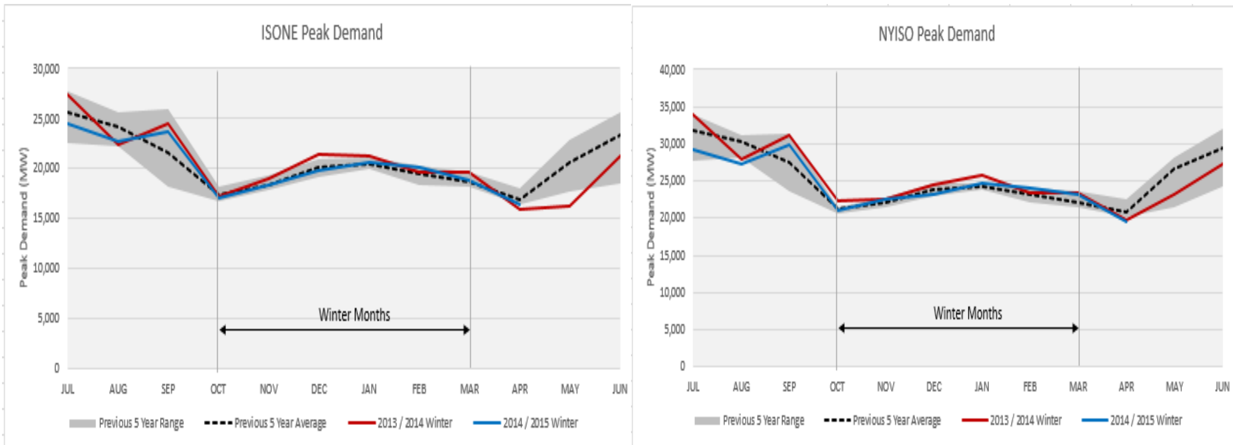
*Figure 5-4 Peak Winter Demands (MW) in MISO in the Winters of 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013*




Source: MISO.

Figure 5-5 illustrates the peak demand levels in ISO-NE and NYISO over the two winters relative to the five-year historic average. These two regions did not experience the extreme peaks that MISO and PJM did during these two winters. While overall consumption in ISO-NE was higher (Table 5-2), peak demand was closer to the five-year average. Similar to ISO-NE, overall demand for electricity in NYISO was consistently higher than average during winters 2013-2014 and 2014-2015. (See Table 5-2). However, the significant increases in peak demand in the winters of 2013-2014 and 2014-2015 as compared to historical levels that were seen in PJM and MISO were not present in NYISO.

*Figure 5-5 Peak Winter Demands (MW) in ISONE and NYISO in the Winters of 2013-2014 and 2014-2015 vs. Prior 5-year Average and Range in 2008-2009 to 2012-2013*




Source: ISO-NE and NYISO.

## Supply

In the United States, electricity supply comes from a wide range of electricity-generating technologies and fuels.[96] In 2014, fossil fuels (coal, natural gas, and petroleum liquids) accounted for 67% of U.S. electricity generation and 89% of installed capacity.[97] In the Midwest, the generation mix mirrors this national profile. However, in New England, over 66% of the generating capacity is natural gas-fired and provides 39% of the generation.[98] Some generators have the ability to use more than one type of fuel — in New England, 4.5% of the capacity is capable of firing natural gas or fuel oil. In New York State, gas-fired generation accounts for about 40% of generation in New York state[99] and 46% is capable of firing natural gas or fuel oil.[100] The characteristics of the electricity generation market — the types of capacity available, the fuel resources used, and the ability to use more than one fuel — all influenced how the market responded to the events of winter 2013-2014 and 2014-2015. Additional discussion of the various aspects of supply during the winters of 2013-2014 and 2014-2015 is provided below.

[96] Electric generating capacity represents the system's ability to meet load at an instant in time and is expressed as megawatts (MW). Electricity generation, expressed as kilowatt-hours (kWh) is the amount of energy that can be supplied over time.

[97] U.S. Energy Information Administration, Monthly Energy Review, July 2015. Preliminary Data. Accessed August 1, 2015. http://www.eia.gov/totalenergy/data/monthly/index.cfm#electricity.

[98] ISO-NE Resource Mix. Accessed August 1, 2015. http://www.iso-ne.com/about/what-we-do/key-stats/resource-mix.

[99] http://www.nyiso.com/public/webdocs/markets_operations/documents/Studies_and_Reports/Reports/Market_Monitoring_Unit _Reports/2014/NYISO2014SOMReport__5-13-2015_Final.pdf.

[100] NYISO. Important of Reliability. Accessed August 1, 2015. http://www.nyiso.com/public/about_nyiso/importance_of_reliability/powering_new_york/index.jsp.

## Fuel Supply Issues

Transportation of fuels to generation facilities is a key component of a reliable electricity supply. As noted in Chapter 4, few areas in the U.S. have direct access to natural gas production fields; hence the availability of pipeline capacity from production areas is a crucial element of gas supply for most U.S. electricity generation markets that rely on natural gas to fuel electricity generation. Regardless of how much natural gas is produced, a constraint on pipeline capacity at any point between production and where it is consumed can limit the availability of gas supplies to the market. For example, electricity generators are occasionally unable to access sufficient natural gas supplies due to pipeline constraints and the fact that generators typically contract for non-firm pipeline capacity and gas supplies under Interruptible Transportation (IT) service tariffs.[101] This impact was evident during the winter of 2013-2014. See box below. High demand for natural gas by priority end users, as well as upstream supply and operational issues (see Chapter 4) caused disruption in the supply of natural gas to generators.

### Fuel Supply Interruptions

***Winter 2013-2014.*** During the peak demand day of January 7, 2014, PJM, already facing significant forced outages in its generating fleet due to the extreme weather, also experienced natural gas interruptions. At that time, more than 25% (9,520 MW[a]) of the total outages on the system were due to natural gas interruptions.[b] During the 2013–2014 winter, ISO-NE lost more than 8,000 MW of its 11,000 MW of gas-fired generation during its peak hour. A majority of these generators were forced out of service due to natural gas supply interruption resulting from non-firm fuel delivery arrangements.[c] In MISO, 4,410 MW of gas-fired generation was unavailable on January 6, 2014; the following day 6,666 MW of gas-fired generation was off line due to lack of fuel.[d]

***Winter 2014-2015.*** During the winter of 2014-2015, PJM experienced almost the same level of interruptions due to natural gas delivery issues–about 7,500 MW at the time of system peak (February 20, 2015)–but the system was able to handle the stress. Improved communications among PJM, pipeline operators, and plant owners, and better performance by dual-fueled generators, improved management of these interruptions. [e] Other fuel-related issues reported during the two winters included coal plants whose coal stockpiles froze and some oil-fired generating units that experienced clogged fuel lines.[f]

*Sources:*

*[a,e] PJM Winter Report 2015, Accessed July 2015: http://www.pjm.com/~/media/documents/reports/20150513-2015-winter-report.ashx*

*[b] PJM Analysis of January 2014, Accessed July 2015: https://www.pjm.com/~/media/documents/reports/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx*

*[c] NERC Reliability Assessment 2014, Accessed August 2015: http://www.nerc.com/pa/RAPA/ra/Reliability%20Assessments%20DL/2014WRA_final.pdf*

*[d] 2013-2014 MISO Cold Weather Operations Report, Midcontinent Independent System Operator, Inc., November 2014. Accessed on August 1, 2015: https://www.misoenergy.org/Library/Repository/Report/Seasonal%20Market%20Assessments/2013-2014%20Cold%20Weather%20Operations%20Report.pdf*

*[e] http://www.pjm.com/~/media/documents/reports/20150513-2015-winter-report.ashx.*

*[f] Analysis of Operational Events and Market Impacts During the January 2014 Cold Weather Events, PJM Interconnection, May 8, 2014. Accessed on August 1, 2015: https://www.pjm.com/~/media/documents/reports/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx.*

---

[101] Addressing Gas Dependence July, 2012, ISO-NE, Strategic Planning Initiative. Accessed August 20, 2015 http://www.iso-ne.com/committees/comm_wkgrps/strategic_planning_discussion/materials/natural-gas-white-paper-draft-july-2012.pdf.

These issues were further complicated by the interdependent relationship between natural gas and wholesale electricity markets, which had been characterized by poor logistical coordination, inefficiencies, and structural misalignments between the two markets. See box below.

**Natural Gas–Electricity Market Misalignments & FERC's Response**

The "gas day"–when natural gas transportation via pipelines is nominated and scheduled – begins at 9:00 AM Central Clock Time (CCT). The electricity day begins earlier, usually at 12:00 AM local time. Therefore, the morning ramp-up in electricity load occurs near the end of the gas day, which provides little flexibility for generators who may need to change their supply and/or transportation arrangements.[a] These market coordination issues were evident in the Northeast during the 2013-2014 winter. Natural gas generators were often unable to secure enough pipeline capacity (as discussed above) and were left with limited options once they became aware of the situation, which had residual consequences on electricity system operators' ability to plan and coordinate.[a]

Following the winter's experience, the Federal Energy Regulatory Commission (FERC) proposed a change in the start of the gas day to 4:00 AM CCT to better coincide with the start of the electric day. FERC declined to adopt the proposal on April 16, 2015.[b] However, FERC did approve changing the closing time for the Timely Nomination Cycle to 1:00 PM CCT. The change allows electricity generators to use this cycle to schedule gas orders after learning if their electricity bids have been selected for the next day.[c] The FERC order also added a third intra-gas day nomination cycle in an effort to provide shippers and electric generators with greater flexibility in scheduling and managing changes in demand.[c]

Sources:

[a] *Coordination of the Scheduling Processes of Interstate Natural Gas Pipelines and Public Utilities, Final Rule, Docket No. RM14-2-000; Order No. 809 18 CFR Part 284, April 16, 2015, http://www.ferc.gov/whats-new/comm-meet/2015/041615/M-1.pdf.*

[b] *FERC Committee Meeting Updates. April 16, 2015. Accessed August 2015: http://www.ferc.gov/whats-new/comm-meet/2015/041615/M-1.pdf*

[c] *"FERC Approves Final Rule to Improve Gas-Electric Coordination," April 16, 2015, Accessed on August 6, 2015: http://ferc.gov/media/news-releases/2015/2015-2/04-16-15-M-1.asp#.VYlw0E3bJ9A*

## Petroleum Use in Dual-Fueled Generators

With the natural gas pipeline capacity constrained across the Northeast, many generators with dual-fuel capabilities turned to liquid petroleum-based fuel oils — distillate fuel oil, residual fuel oil, diesel (No. 1, No. 2, and No. 4), propane, and jet fuels — during this time.[102] Figure 5-6 shows the impact of this fuel switching on the electricity generation fuel mix in ISO-NE during January and February (combined, unweighted average of the two months) in 2014 and 2015 compared to the three-year historical average. In ISO-NE, the share of generation from natural gas in January and February dropped noticeably in the winters of both 2013-2014 and 2014-2015 compared to historical averages — by 14 and 10 percentage points, respectively. In contrast, the use of fuel oils increased substantially during those time periods. In January and February 2014 petroleum's contribution to the generation mix increased to 8%, compared to the three-year historical average of 1%. In January and February 2015 petroleum's contribution to the generation mix was 10%, compared to the three-year historical average of 1%. In NYISO a similar trend was observed: fuel oil contributed to about 7% of the generation mix in January and February of both 2014 and 2015, compared to historical averages of 1.5%.[103]

---

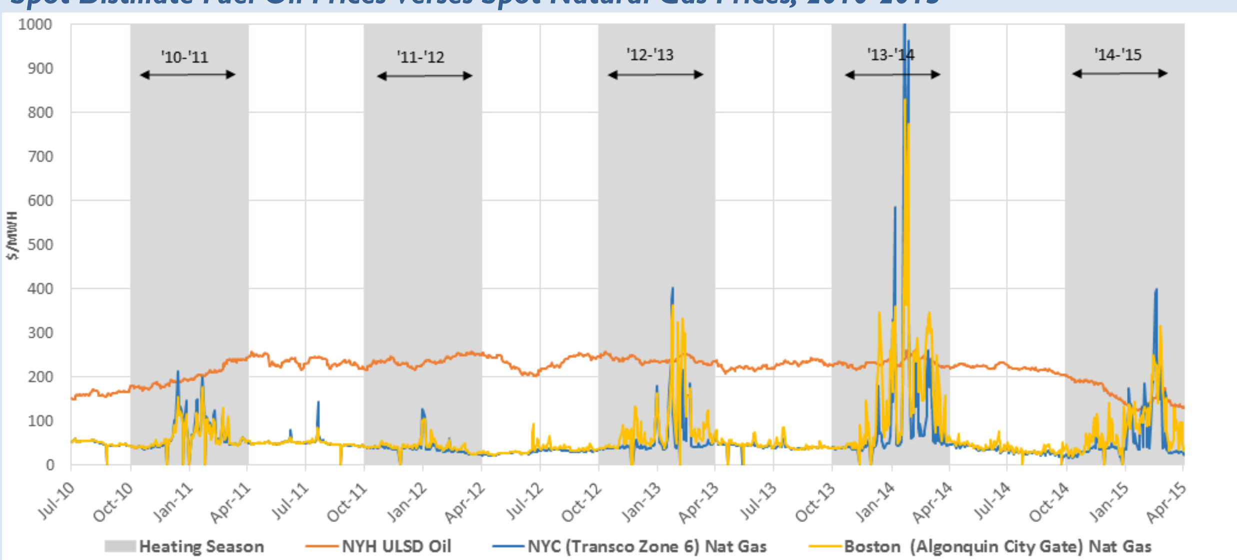
[102] In EIA survey data (and Figure 5-5) these fuels are collectively called "petroleum liquids". In this chapter they are referred to as "fuel oil".

[103] EIA Survey Form 923.

## Economics of Dual Fuel Switching During the Winters of 2013-2014 and 2014-2015

Generators that have the capability to burn either natural gas *or* fuel oil have an added degree of flexibility when making operating decisions. This flexibility is particularly beneficial when systems are stressed or when severe weather events disrupt normal operating procedures. During the winters of 2013-2014 and 2014-2015 some generators with dual-fuel burning capabilities switched from natural gas to fuel oil. At times the switch was motivated by natural gas supply shortages created by the limited pipeline capacity into New England, as discussed throughout this report. Other times the switch reflected the relative economics of generating with natural gas vs. with fuel oil—on some days it was simply less expensive to use fuel oil instead of natural gas. The figure below shows the relative cost of fuel for generation, expressed in $/MWh, over the July 2010 to April 2015 time period. The highest spot natural gas price was recorded in January 2014 when NYC Transco Zone 6 reached roughly 1200 $/MWh. These dispatch costs are estimates, based on an assumed generator efficiency of 10,549 Btu/kWh[a], and not accounting for transportation cost for either fuel. Moreover, there is a small efficiency penalty (~5%) when switching from natural gas to oil. Nonetheless, these figures indicate that during certain periods of winter 2013-2014 and 2014-2015 (especially during the peak months of January 2014 and February 2015) natural gas prices spiked, making oil significantly more attractive for economic dispatch.

***Spot Distillate Fuel Oil Prices Verses Spot Natural Gas Prices, 2010-2015[b]***



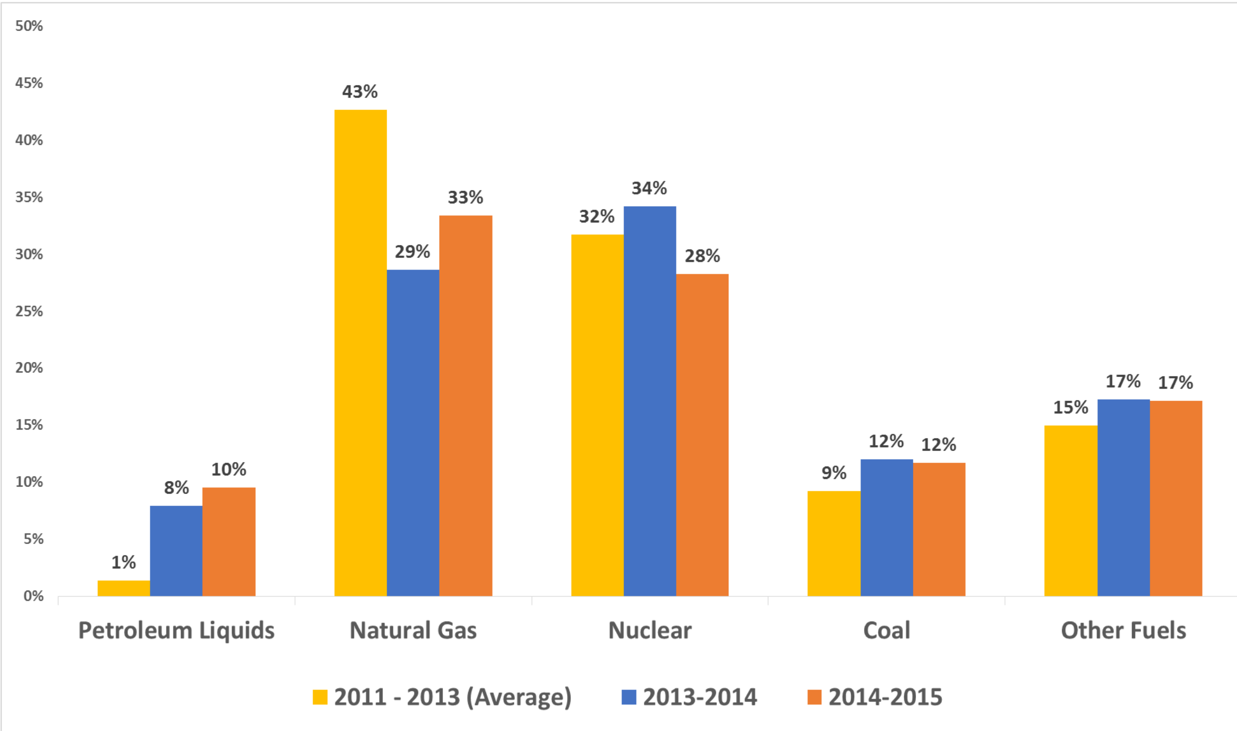

Many generators with the capability to burn either fuel opted to switch from natural gas to oil during these times to take advantage of the market conditions.[c] The economics of making this switch were favorable at times in January 2014 and February 2015. As shown in the table to the right, the NYH ULSD Oil price was lower than the NYC Transco 6 Natural Gas price during 16% of days in January 2014 and 40% of days in February 2015, compared to very few times, if at all, during the same months in 2010-2013.

**Number of Days When NY Harbor ULSD Oil Price was Lower than NYC Transco Zone 6 Natural Gas Price**

| | Jan | Feb |
|---|---|---|
| 2010 | 0 | 0 |
| 2011 | 0 | 0 |
| 2012 | 0 | 0 |
| 2013 | 3 | 0 |
| 2014 | 9 | 1 |
| 2015 | 5 | 12 |

[a] *Based on EIA* see http://www.eia.gov/tools/faqs/faq.cfm?id=107&t=3
[b] *EIA, Reuters*
[c] *PJM Winter Report 2015*

*Figure 5-6 Average Generation Mix in ISO-NE in January and February, Winters 2013-2014 and 2014-2015, in Comparison to 3-year Average*




Averages are simple, unweighted averages.
Source: EIA Form 923. Petroleum liquids includes distillate fuel oil, residual fuel oil, kerosene, jet fuel and propane.

Dual-fuel-capable capacity increases system flexibility and reliability. Nonetheless, some generators encountered problems when they tried operating on fuel oil. Some generation owners faced restrictions on the amount of time they could burn fuel oil due to environmental limits established by their operating permits. PJM estimated that approximately 1,000 MW of generation were affected by these constraints.[104]

The large number of units across the Northeast switching to fuel oil also created resupply challenges. In some cases, run time was reduced because fuel oil suppliers were unable to deliver supplies when inventories ran low and not enough delivery trucks were available. PJM reported that during the winter 2013-2014, approximately 2,000-3,000 MW of generation were affected by fuel oil supply and delivery issues.[105]

During the winter of 2014-2015, industry participants took several preemptive actions to avoid repeating the situations encountered the previous year. These included measures associated

---

104 PJM Analysis of Operational Events. Accessed August 1, 2015. https://www.pjm.com/~/media/documents/reports/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx.

105 PJM Analysis of Operational Events. Accessed August 1, 2015. https://www.pjm.com/~/media/documents/reports/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx.

with the ISO-NE Winter Reliability Program[106] and improved gas-electric coordination, among others. These changes are discussed in the next section. Combined with sharp decreases in global oil prices, these actions improved the economics of oil as a fuel for generation. This relieved pressure on the gas market because dual-fuel plants were able to switch to fuel oil at lower prices. Consequently, oil-fired generation in New England increased by roughly 200,000 MWh during winter 2014-2015.[107] However, as discussed in Chapter 2, the use of distillate fuel oil in power generation in turn put stress on the distillate fuel oil markets. The improved economics of distillate relative to natural gas brought more buyers into the market, including power plants that typically only use distillate as a back-up source and have limited inventory on site for continuous operation.[108] The increase in demand helped contribute to a spike in prices that was significantly above previous winter price peaks.

### Equipment Outages

Many regions experienced equipment problems caused by the extreme weather. Figure 5-7 compares the causes of forced outages in PJM during the winter peak days of 2013-2014 and 2014-2015. In PJM, many gas-fired generators experienced forced outages during the winters of 2013-2014 and 2014-2015. In 2013-2014, gas interruptions caused 9,520 MW of forced outages during the January peak (24% of total forced outages) in PJM. The following winter, generation owners and system operators took precautions such as adding additional freeze protection, implementing a winter preparation checklist, and undergoing cold weather exercises. These measures helped decrease outages forced by peak-demand days, such as, outages caused by natural gas interruptions which resulted in a decrease of 2,100 MW; weather-related outages which dropped by 5,300 MW and outages related to fuel ignition and combustion systems resulting in a decrease of 1,200 MW.[109] In total, forced outages decreased by roughly 11,000 MW in PJM.[110]

---

106 FERC Order Accepting Tariff Revisions, Docket Nos. ER14-2407-000-002. ISO New England, Inc. and New England Power Pool Participants Committee. September 9, 2014.

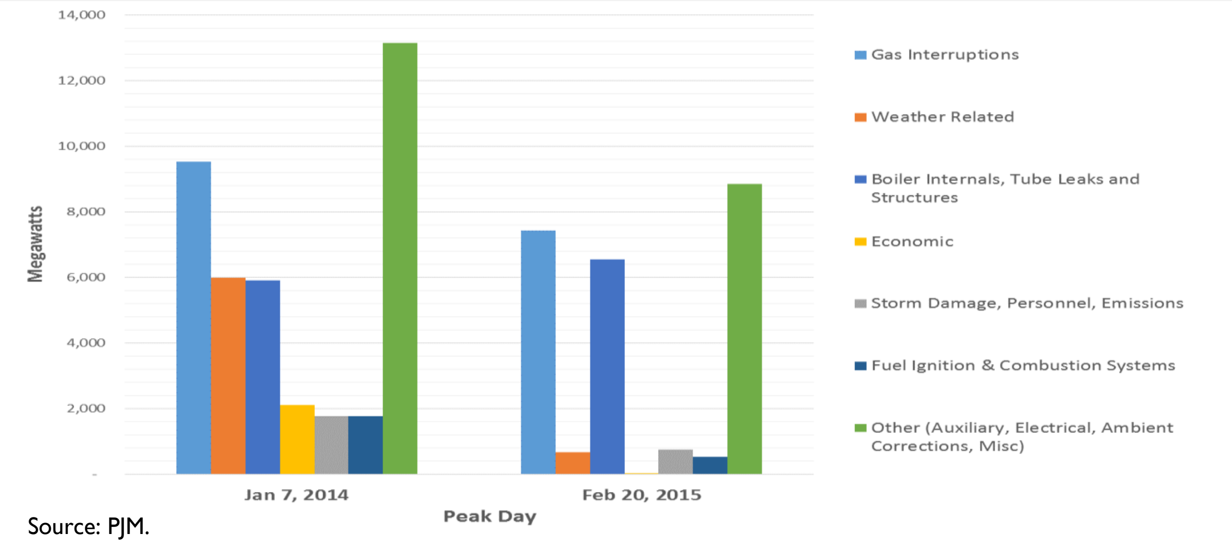
107 EIA Survey Form 923.

108 ISONE. Annual Report 2014. http://www.iso-ne.com/aboutiso/fin/annl_reports/2000/2014_reo.pdf.

109 The number of units expected to be available may have differed between years.

110 2015 Winter Report, PJM Interconnections, May 13, 2015, Accessed August 1, 2015. http://www.pjm.com/~/media/documents/reports/20150513-2015-winter-report.ashx.

*Figure 5-7 Causes of Forced Outages in PJM During Peak Days in Winters of 2013-2014 and 2014-2015*

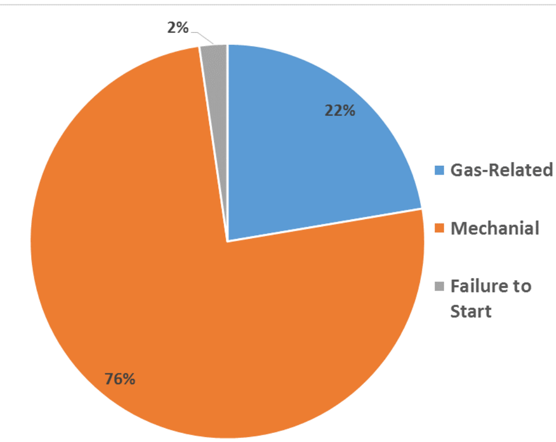



Source: PJM.

The addition of new natural gas pipeline capacity contributed to the overall improvement in PJM's system performance during the winter of 2014-2015. In November 2014, the Texas Eastern pipeline added 600 MMcf/d capacity in New York, New Jersey, and Pennsylvania.[111] Increased natural gas storage inventories, and enhanced communications between PJM, gas pipeline operators and plant owners all helped improve generator and overall system performance.

While MISO's natural gas pipeline capacity constraints are not as severe as those that persist in PJM and ISO-NE, high natural gas demand in neighboring regions and low availability coupled with severe cold did have an impact on the MISO market. This is reflected in gas-related forced outages, which occurred during winter 2013-2014. Figure 5-8 shows forced outage causes in MISO in January 2014; gas-related outages accounted for 22% of total outages. MISO and PJM worked together closely to effectively manage these severe weather events, importing and exporting power to each other as necessary during emergency situations.[112]

*Figure 5-8 Causes of Forced Outages (MW) in MISO, January 2014*




Source: MISO.

[111] Winter Report 2015. PJM Interconnections. May 13, 2015. Accessed June 2015 via http://www.pjm.com/documents/reports.aspx and Texas Eastern Appalachia to Market 2014 (TEAM 2014); http://www.spectraenergy.com/Operations/New-Projects-and-Our-Process/New-Projects-in-U.S./Texas-Eastern-Appalachia-to-Market-2014-TEAM-2014/.

[112] 2013-2014 MISO Cold Weather Operations Report, Midcontinent Independent System Operator, Inc., November 2014. Accessed on August 1, 2015https://www.misoenergy.org/Library/Repository/Report/Seasonal%20Market%20Assessments/2013-2014%20Cold%20Weather%20Operations%20Report.pdf.

## Operational Changes Implemented in Winter 2014-2015

As previously noted, the winter of 2014-2015 was characterized by less volatile electricity and natural gas prices and greater market stability. The improvement was partially due to the more favorable weather pattern, and some of the improved conditions reflect preemptive actions taken by industry. This included new operational procedures and policy changes designed to avoid the issues experienced during the winter of 2013-2014. Notable operation and policy changes implemented are outlined in Table 5-4.

Of particular note is ISO-NE's second Winter Reliability Program. While the program was in place during winter 2013-2014, several changes were made to strengthen its effects. For example, during the 2014-2015 program, generators were incentivized to build upfront inventory through payments that helped offset some of the carrying costs of their unused oil inventory and LNG contracts. [113] This adjustment to the compensation structure also helped to incentivize natural gas-fired generators to contract for LNG as a peak operations fuel. In total, 79 oil and duel-fuel fired units participated, collectively compiling more than four million barrels of reserves. This is equivalent to each unit storing enough oil for 15 days of operation or 95% of their usable fuel storage capability (each unit was eligible for compensation for the lesser).[114]

Demand-response actions – the incentive-based programs that encourage electric power customers to temporarily reduce their demand for power, thereby helping to reduce overall stress on the system during vulnerable periods caused by excess demand or extreme events — were used during the winter of 2013-2014 by PJM on January 7, 2014. The first call for voluntary load reductions was for about 1,000 MW and the second later in the day was for about 3,000 MW. This represented about 20% of the available resources in PJM.[115] NYISO activated voluntary reduction from about 900 MW of its demand resources on January 7. ISO-NE's called on 21 MW of demand response on five occasions during the winter. MISO did not activate their demand response programs during the 2013-2014 winter events.[116]

Demand response resources were minimally used during the 2014-2015 winter. NYISO met all operating reliability criteria over the winter 2014-2015 peak without any statewide supplemental capacity commitments and demand-response notifications or activation.[117] PJM, despite setting a new record winter peak, required no emergency demand response or other capacity emergency actions. This was mainly due to better generator performance, fewer forced outages, and availability of greater levels of generation, both internally and externally.[118] In ISO-NE demand-response resources (14 MW participating) were activated only once.[119]

---

113 Federal Energy Regulatory Commission, Order 61179, Docket Nos ER14-2407-000-002, September 9, 2014. Accessed August 1, 2015: http://www.ferc.gov/CalendarFiles/20140909165718-ER14-2407-000.pdf

114 Enerknol, ISO-NE Details 2014/2015 WRP Resource Participation, Accessed September 9, 2015, https://enerknol.com/iso-ne-details-20142015-wrp-resource-participation/

115 PJM Report, Analysis of Operational Evens. Accessed August 1, 2015 https://www.pjm.com/~/media/documents/reports/20140509-analysis-of-operational-events-and-market-impacts-during-the-jan-2014-cold-weather-events.ashx.

116 Winter 2013-2014 Operations and Market Performance in RTOs and ISOs, Staff Report, April 1, 2014, AD14-8-000. Accessed on July 24, 2014. http://www.ferc.gov/legal/staff-reports/2014/04-01-14.pdf.

117 Winter 2015 Cold Weather Operations Report from NYISO from 3.31.15. Accessed June 2015 via *www.nyiso.com.*

118 PJM Winter Report 2015. Accessed June 2015 via http://www.pjm.com/documents/reports.aspx.

119 ISONE, ISO Newswire New England Power System Performed Well Through Winter. Accessed August 1, 2015 http://isonewswire.com/updates/2015/4/7/new-england-power-system-performed-well-through-winter-20142.html.

*Table 5-4 Operational and Policy Changes Implemented in Winter 2014-2015[a]*

| ISO | Change Implemented | Result During Winter 2014-2015 |
|---|---|---|
| **Expanded pre-winter preparation and reliability testing** | | |
| ISO-NE | Expanded winter reliability testing to include dual-fuel conversion facilities. | Overall participation in winter preparation increased and facilities were better able to handle weather events and cold temperatures |
| ISO-NE | Adjusted winter reliability compensation structure. | Oil-burning generators were encouraged to rely on upfront inventory[b] and given reassurances via end-of-season payment help to offset carrying costs of leftover inventory[c] |
| PJM | Expanded pre-winter testing to include dual-fuel and infrequently run units. 168 units participated. | All units that participated (9,919 MW)[d] in pre-winter testing exhibited lower rates of forced outages compared to non-participating units. |
| PJM | PJM utilized winter 2013-2014 data in its load forecasting tool to improve accuracy. | In February 2015 the average load forecasting error for the four highest peak days was only 1.52% compared to 5.29% for the six highest peak days in January 2014. The improvement is equivalent to 1,050 MW of load.[d] |
| PJM | Adjusted emergency communications procedures and clarified roles and responsibilities for each participating party. | During the winter peaks PJM was able to staff the operational readiness team more quickly to provide the extra analysis and support needed by dispatchers. |
| **Enhanced communication, streamlined information and increased data utilization** | | |
| MISO | Implemented a policy to facilitate communication between control rooms and the more than 70 pipeline operators who serve gas-fired generation. | Improved response time and information sharing between system participants. |
| MISO | Introduced a real-time mapping tool[e] which displayed gas-fired units tied into its jurisdictional pipelines. | Facilitated better anticipation of forced outages and more robust communication between operators and other industry participants. Critical notices on pipeline status could be consolidated in one place. |
| NYISO | Expanded its "natural gas system visualization" by adding an Energy Management System (EMS).[f] | Operators were expected to have a better grasp on pipeline activity and conflicts. |
| ISO-NE | Introduced regular conference calls with NPCC Reliability Coordinators and conducted more routine reviews of gas purchases via pipeline Electronic Bulletins. | Expanded communication practices helped ensure grid reliability during the extremely cold days. |
| **Improved generation availability, performance, and flexibility** | | |
| PJM | Gave generators more ability to change cost offers intraday and increased the offer cap to $1,800 through 3/31/15. | Allowed generators to recover more of their costs during peak demand periods when fuel input prices are otherwise restrictively high.[g] |
| ISO-NE | Allowed generators to update their offers intraday. | This action increased the financial incentives for owners to improve generator plant performance and significantly increased generator flexibility.[c] |
| PJM | Established an internal gas-electric coordination team to provide information and analysis regarding the impact of natural gas fuel supply on generator availability. | Facilitated more transparency and availability of information about generator activity, insight into pipeline restrictions, durations, forecasts, and overall status.[d] |

Source Notes:

a. Information gathered from MISO, ISO-NE, NYISO and PJM reports and presentations

b. FERC Order Accepting Tariff Revisions, Docket Nos. ER14-2407-000-002. ISO New England, Inc. and New England Power Pool Participants Committee. September 9, 2014

c. ISO-NE Winter 2014-2015 Presentation. Accessed June 2015 via http://www.iso-ne.com/static-assets/documents/2015/06/winter_2014_15_review.pdf

d. Winter Report 2015. PJM Interconnections, May 13, 2015. Page 6. Accessed June 2015 via http://www.pjm.com/documents/reports.aspx

e. MISO Mapping Tool. *https://www.misoenergy.org/AboutUs/MediaCenter/PressReleases/Pages/MISOPreparedforWinterPowerDemand.aspx*

f. Bulk Electric System Preparedness Report, 2014-2015. New York State Department of Public Services, Office of Electric, Water, and Gas. October 23, 2014. Accessed on August 1, 2015: http://www3.dps.ny.gov/pscweb/WebFileRoom.nsf/ArticlesByCategory/5B02699074171067852 57D74006BF061/$File/pr14063.pdf?OpenElement

g. In some cases they still could not recover costs with that offer cap. FERC was working with ISOs to retroactively "make whole" the generators.

*This page intentionally blank*

# 6. Conclusions

The winters of 2013-2014 and 2014-2015 were among the coldest in recent history, emphasizing that weather remains a primary driver of consumer demand, infrastructure utilization, and commodity price behavior in the U.S. power and fuels markets.

After several consecutive *warmer*-than-normal winters in the Northeast and Midwest, the return of *colder*-than-normal winter conditions increased demand, stressed energy systems, and resulted in price spikes that had significant impacts on consumers. The unique characteristics and timing of the weather patterns during the last two winters contributed substantively to the challenges that markets faced.

In the winter of 2013-14, energy markets endured continuously colder-than-normal temperatures across broad geographic areas in much of the Eastern Seaboard and Midwest. A later than normal, wet fall season increased grain-drying demands, followed by consistently colder-than-normal temperatures which reduced propane storage inventories below normal levels and stressed propane market supplies. Distillate fuel oil inventories were also low at the beginning of the winter heating season, creating tight fuel markets.

While abnormal cold temperatures played a large role in market behavior during these two winters, other factors also trigged volatility in the fuel and power markets. In 2013-2014 and 2014-2015, it was a confluence of unplanned events concurrently with abnormal weather that presented the greatest challenges to service reliability. These interactions created an added layer of complexity and made it difficult to accurately predict whether utilities, their suppliers and markets in general were sufficiently prepared for all potential outcomes. Disruptions in the power and fuel supply markets sent prices soaring.

Because power and fuels markets are increasingly integrated, linkages were evident in the Northeast when natural gas-fired power plants were unexpectedly unable to obtain gas, requiring many with dual-fuel capability to switch to fuel oil, which was already in short supply. The heightened demand for natural gas and distillate fuel oil for power drove spot natural gas and distillate prices sharply upward, and those price spikes led to volatile regional wholesale power market prices. Likewise, tight natural gas and propane supplies in the Midwest contributed to price spikes which impacted consumer prices. The interdependencies between integrated, but distinct, markets can be particularly difficult to forecast or manage.

The experiences of 2013-2014, however, brought greater focus on planning and coordination between the power and natural gas industries. Power grid operators instituted improved incentives to have fuel oil/distillate stocks available for plants in the event of natural gas supply disruptions, and to draw on Demand Response resources. Gas buyers also integrated increased purchases of international LNG imports into New England gas markets. Propane customers and dealers implemented plans that included adding storage capacity and building propane inventories earlier in the season. These measures likely mitigated the effects of the 2014-2015 winter, and were a key component of the greater supply availability across markets with lower prices. Lastly, increased domestic natural gas production and lower global oil prices also mitigated supply and price impacts.

New insights gained from the winters of 2013-2014 and 2014-2015 experience will help as industry prepares for future winter trends. For example, following the winter of 2013-2014, the National Propane Gas Association (NPGA) created a Supply and Infrastructure Task Force to analyze the issues faced during the winter and to provide recommendations for the industry going forward. Recommendations[120] included increasing the use of storage on both the customer and marketer level, improving demand forecasting, and initiating permanent changes to transportation and logistics such as increasing the Federal weight allowance for propane transports to 85,000 lbs.[121] Other proposals for improving transportation included increasing the use of railroad and truck distribution to provide more delivery flexibility.[122]

Additionally, the US Energy Information Administration implemented several permanent data initiatives for all types of heating fuels. These include providing more detailed weekly propane stock data; notifying governors when stocks of heating oil, natural gas, or propane fall below the 5-year average in their PADD for more than three weeks; and increasing the number of State Heating Oil and Propane Program (SHOPP) participants from 24 states to 38 states.[123] In addition, the EIA introduced a new website to improve the accessibility and visibility of each state's weekly pricing and storage data for heating oil, natural gas, and propane data.[124]

Looking forward to the coming winter, programs initiated in the regional power markets to firm up the availability of generating resources during the winter season should contribute to fewer incidents of the market failures that caused power plant operators to rush unexpectedly into spot natural and fuel oil markets. The New England ISO's Winter Reliability program demonstrated value in mitigating market impacts during the last two winters. For the next several years, FERC is expected to use a similar winter reliability program for the New England region proposed by the New England Power Pool (NEPOOL).[125] As a long-term solution, FERC has approved ISO-NE's Pay-for-Performance Initiative (PI), a system which will reward generators that over-perform and penalize those that under-perform starting in 2018.[126] Additionally, PJM, for example, implemented a Capacity Performance standards program that

---

120 Note: The Task Force's recommendations were *not* binding decisions or legal requirements, simply suggestions for industry participants to follow in an effort to prevent future shortages.

121 National Propane Gas Association. Propane Supply Planning. May, 2014. http://www.npga.org/files/FINAL%20Recommendations%20of%20Marketer%20Education%20Working%20Group(1).pdf

122 Michigan Public Service Commission. Heating oil and propane price survey. 2013-2014 Review. http://michigan.gov/documents/mpsc/shopp13-14_464988_7.pdf

123 Energy Information Administration. State Heating Oil and Propane Program. October 8, 2015. http://www.eia.gov/petroleum/heatingoilpropane/workshop/pdf/shoppprogram.pdf

124 Energy Information Administration. Winter Heating Fuels. http://www.eia.gov/special/heatingfuels/#/US:propane:week

125 Note: In September 2015 FERC choose a winter reliability program proposed by the New England Power Pool (NEPOOL) instead of one proposed by ISO-NE. FERC will use NEPOOL's proposal for the next three years. Additional information can be found at http://nepool.com/Litigation_Reports.php.

126 ISO-NE. FCM Performance Incentives. Accessed October 6, 2015. http://www.iso-ne.com/committees/key-projects/fcm-performance-incentives

offered new revenue opportunities to plant operators willing to guarantee availability, with stiff penalties for failure.[127] An August auction for 2016-2017 Capacity Performance bids successfully obtained competitive bids to meet market requirements.[128] These programs by PJM and other regions should contribute to improved reliability and lower price volatility in both the power and fuels market this coming winter.

[127] PJM. Capacity Performance Proposal. Accessed August 1, 2015. https://pjm.com/~/media/documents/reports/20141007-pjm-capacity-performance-proposal.ashx.

[128] PJM. Capacity Performance Transitional Auction Ensures Availability of Resources. Accessed August 1, 2015. http://www.prnewswire.com/news-releases/pjm-capacity-performance-transitional-auction-ensures-availability-of-resources-to-maintain-reliable-power-supplies-for-2016-2017-300135569.html.

*This page intentionally blank*

# Glossary

**Algonquin, City-Gates:** Deliveries from Algonquin Gas Transmission to all distributors and end-use facilities in Connecticut, Massachusetts and Rhode Island. See also Citygate below.

**Backup generator:** A generator that is used only for test purposes, or in the event of an emergency, such as providing power needed during a shortage to meet customer load requirements.

**Backup power:** Electric energy supplied by a utility to replace power and energy lost during an unscheduled equipment outage.

**Barrel (bbl):** A unit of volume equal to 42 U.S. gallons.

**bbl/d:** The abbreviation for barrel(s) per day.

**bcf:** The abbreviation for billion cubic feet.

**Bottled gas, LPG, or propane:** Any fuel gas supplied to a building in liquid form, such as liquefied petroleum gas, propane, or butane. It is usually delivered by tank truck and stored near the building in a tank or cylinder until used.

**British thermal unit (BTU):** The quantity of heat required to raise the temperature of 1 pound of liquid water by 1 degree Fahrenheit at the temperature at which water has its greatest density (approximately 39 degrees Fahrenheit). BTUs are a common unit for natural gas.

**Bulk terminal:** A facility used primarily for the storage and/or marketing of petroleum products, which has a total bulk storage capacity of 50,000 barrels or more and/or receives petroleum products by tanker, barge, or pipeline.

**Citygate:** A point or measuring station at which a distributing gas utility receives gas from a natural gas pipeline company or transmission system.

**Consumption:** Total resource consumed by a relevant entity.

**Conway:** Propane processing, storage, and price hub located at Conway KS.

**Demand:** The requirement for energy as an input to provide products and/or services.

**Demand Response:** Demand response programs are incentive-based programs that encourage electric power customers to temporarily reduce their demand for power at certain times in exchange for a reduction in their electricity bills.

**Desulfurization:** The removal of sulfur, as from molten metals, petroleum oil, or flue gases.

**Distillate fuel oil:** A general classification for one of the petroleum fractions produced in conventional crude oil distillation operations. It includes **Diesel** fuels and **Heating** oils. **Diesel** products used in on-highway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery, all must meet a maximum 15 ppm sulfur limit (the product is known as Ultra Low Sulfur Diesel, or ULSD). Products used primarily for space heating (known as **Heating Oil,** or **No. 2 Fuel Oil**) and electric power generation are similar fuels, although sulfur levels can be higher depending upon State regulations.

**Dominion, South Point:** A natural gas pricing point located in southwest Pennsylvania. Deliveries at this point are into two Dominion Transmission main lines: one runs northeast from Warren County, OH, midway between Cincinnati and Dayton, and merges with the second line just northeast of Pittsburgh, PA. The second line runs from Buchanan County, VA, on the Virginia/West Virginia border north to the end of the zone at Valley Gate in Armstrong County, PA.

**Eastern Interconnect:** The Eastern Interconnection is one of the two major alternating current (AC) power grids in North America. All of the electric utilities in the Eastern Interconnection are electrically tied together during normal system conditions and operate at a synchronized frequency operating at an average of 60 Hz. The Eastern Interconnection reaches from Central Canada eastward to the Atlantic coast (excluding Quebec), south to Florida, and back west to the foot of the Rockies (excluding most of Texas).

**Energy consumption:** The use of energy as a source of heat or power or as a raw material input to a manufacturing process.

**Energy supplier:** Fuel companies supplying electricity, natural gas, fuel oil, kerosene, or LPG (liquefied petroleum gas) to households.

**Energy supply:** Energy made available for future disposition. Supply can be considered and measured from the point of view of either the energy provider or the receiver.

**Federal Energy Regulatory Commission (FERC):** The Federal agency with jurisdiction over interstate electricity sales, wholesale electric rates, hydroelectric licensing, natural gas pricing, oil pipeline rates, and gas pipeline certification. FERC is an independent regulatory agency within the Department of Energy and is the successor to the Federal Power Commission.

**Firm Transportation Rights (FT):** These are fuel delivery contracts that are not subject to interruptions.

**Florida Gas Transmission, Zone 3:** Deliveries into Florida Gas Transmission downstream of compressor station 8 to just upstream of station 12 in Santa Rosa County, FL, the demarcation point with the market.

**Forced Outage:** The shutdown of a generating unit, transmission line, or other facility for emergency reasons or a condition in which the generating equipment is unavailable for load due to an unanticipated breakdown.

**Fractionation:** The process by which saturated hydrocarbons are removed from natural gas and separated into distinct products, or "fractions," such as propane, butane, and ethane.

**Fuel switching capability:** The short-term capability of a manufacturing establishment to use substitute energy sources in place of those actually consumed. Capability to use substitute energy sources means that the establishment's combustors (for example, boilers, furnaces, ovens, and blast furnaces) had the machinery or equipment either in place or available for installation so that substitutions could actually have been introduced within 30 days without extensive modifications. Fuel-switching capability does not depend on the relative prices of energy sources; it depends only on the characteristics of the equipment and certain legal constraints.

**Grain Drying:** The process of drying grain to prevent spoilage during storage.

**Harvest:** The process or period of gathering in crops.

**Heating Degree Day (HDD):** HDD is a measure of how cold a location is over some period of time relative to a base temperature, most commonly specified as 65 degrees Fahrenheit. HDD is computed for each day by subtracting the average of the day's high and low temperatures from the base temperature (65 degrees), with negative values set equal to zero. Each day's heating degree days are summed to create a HDD measure for a specified reference period (e.g., a month, a heating season).

**Henry Hub:** An outlet on the Sabine Pipe Line, located in Erath, LA, which is connected to a number of interstate pipelines including Gulf South Pipeline, Southern Natural Gas, Natural Gas Pipeline of America, Texas Gas Transmission, Columbia Gulf Transmission, Transcontinental Gas Pipe Line, Trunkline Gas, Jefferson Island Pipeline and Acadian Gas.

**Independent System Operator (ISO):** An independent, federally regulated entity established to coordinate regional transmission in a non-discriminatory manner and ensure the safety and reliability of the electric system.

**Intercontinental Exchange (ICE):** The market that facilitates the electronic exchange of energy commodities. ICE is linked to individuals and firms looking to trade in oil, natural gas, jet-fuel, emissions, electric power and commodity derivatives.

**Interruptible Transportation Rights (IT):** A fuel delivery contract that allows curtailment or cessation of service at the pipeline's discretion under certain circumstances specified in the service contract.

**ISO New England (ISO-NE):** The Independent System Operator for the New England region (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island).

**Liquefied Natural Gas (LNG):** Natural gas (primarily methane) that has been liquefied by reducing its temperature to -260 degrees Fahrenheit at atmospheric pressure.

**Marcellus Shale:** This natural gas formation stretches from upstate New York, south through Pennsylvania, West Virginia, and parts of Southeast Ohio. The Marcellus Shale is located within the Appalachian Basin.

**Mbbl/d:** The abbreviation for thousand barrel(s) per day.

**Megawatt:** One million watts of electricity.

**Megawatt hour (MWh):** One thousand kilowatt-hours or 1million watt-hours.

**Mid-Atlantic Census Region:** New Jersey, New York, and Pennsylvania.

**Mid-Atlantic:** For the purposes of the Electric Power Markets chapter of this report, the Mid-Atlantic refers to the approximate areas serviced by PJM.

**Midcontinent ISO (MISO):** The Independent System Operator for the middle region of the United States.

**Midwest Census Region:** Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin.

**Million Cubic Feet/Day (MMcf/d):** Million ($10^6$) cubic feet.

**MMBtu:** The abbreviation for million British thermal units.

**Mont Belvieu:** Propane processing, storage, and price hub located at Mont Belvieu, TX.

**Natural Gas Liquids (NGL):** A group of hydrocarbons including ethane, propane, normal butane, isobutane, and natural gasoline. Generally includes natural gas plant liquids and all liquefied refinery gases except olefins.

**New England:** Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont.

**New York ISO (NYISO):** The Independent System Operator for New York state.

**Northeast:** Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont.

**Northeast Census Region: Comprises** New England Census division and Mid-Atlantic Census division.

**PADD:** Petroleum Administration for Defense (PAD) District

**Peak demand/consumption:** The maximum load during a specified period of time.

**PJM Interconnection (PJM):** The Regional Transmission Organization that covers the Mid-Atlantic Region.

**Products Supplied:** A proxy for consumption of petroleum products, it measures the disappearance of these products from primary sources, i.e., refineries, natural gas processing plants, blending plants, pipelines, and bulk terminals. In general, product supplied of each product in any given period is computed as follows: field production, plus renewable fuels and oxygenate plant net production, plus refinery and blender net production, plus imports, plus net receipts, plus adjustments, minus stock change, minus refinery and blender net inputs, minus exports.

**Refiner:** A firm or the part of a firm that refines products or blends and substantially changes products, or refines liquid hydrocarbons from oil and gas field gases, or recovers liquefied petroleum gases incident to petroleum refining and sells those products to resellers, retailers, reseller/retailers or ultimate consumers. "Refiner" includes any owner of products that contracts to have those products refined and then sells the refined products to resellers, retailers, or ultimate consumers.

**Regional Transmission Organization (RTO):** An organization that is responsible for moving electricity over large interstate areas. It coordinates, controls, and monitors an electricity transmission grid.

**Retailer:** A firm (other than a refiner, reseller, or reseller/retailer) that carries on the trade or business of purchasing refined petroleum products and reselling them to ultimate consumers without substantially changing their form.

**Spot-market price:** See spot price.

**Spot price:** The price for a one-time open market transaction for near-term delivery of a specific quantity of product at a specific location where the commodity is purchased at current market rates. See also spot market terms associated with specific energy types.

**Spot purchases:** A single shipment of fuel or volumes of fuel purchased for delivery within one year. Spot purchases are often made by a user to fulfill a certain portion of energy requirements, to meet unanticipated energy needs, or to take advantage of low fuel prices.

**Stocks:** Inventories of fuel stored for future use.

**Storage capacity:** The amount of energy an energy storage device or system can store.

**Supply:** The components of petroleum supply are field production, refinery production, imports, and net receipts when calculated on a PAD District basis.

**Supply, petroleum:** A set of categories used to account for how crude oil and petroleum products are transferred, distributed, or placed into the supply stream. The categories include field production, refinery production, and imports. Net receipts are also included on a Petroleum Administration for Defense (PAD) District basis to account for shipments of crude oil and petroleum products across districts.

**TETCO M1 30-inch:** Deliveries into Texas Eastern Transmission on the 30-inch line at the Kosciusko, Mississippi, compressor station, which is the demarcation point between Texas Eastern's production and market zones. Deliveries into the 24-inch mainline are not included.

**Timely Nomination Cycle:** The timing cycle during which nominations are received for the next day's business or for subsequent days when natural gas planning/bidding occurs.

**Transco Z5:** Gas deliveries from Transcontinental Gas Pipe Line on the 30-inch, 36-inch, and 42-inch lines from the Georgia/South Carolina border to the Virginia/Maryland border. Deliveries into Transco at the Pleasant Valley receipt point near Fairfax, VA, from Dominion's Cove Point LNG terminal are not included.

**Transco Z6 (NY):** Deliveries from Transcontinental Gas Pipe Line at the end of Zone 6 into city-gates downstream of Linden, NJ, for New York City area distributors – KeySpan Energy Delivery and Consolidated Edison Co. of New York – as well as Public Service Electric and Gas of New Jersey.

**ULSD (Ultra Low Sulfur Diesel):** Distillate fuel oil with a maximum 15 ppm (parts per million) sulfur content. ULSD is used primarily in transportation fuels and off-road engines. In New York, fuel used for space heating must have a maximum sulfur content of 15 ppm; ULSD can be used for space heating in any market.

**Ventura:** Deliveries to Northern Natural Gas at Ventura in Hancock County, IA.

*This page intentionally blank*