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Short-Term Energy Outlook Supplement: Weather Sensitivity in Natural Gas Markets

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Summary

Residential and commercial sector consumption of natural gas typically triples between the summer (April – September) and winter (October – March) because of demand for space heating (Table 1). The swing in natural gas consumption is primarily met by stock builds during the summer and stock draws during the winter. Higher natural gas spot prices during the winter also contribute to some reduction in natural gas use for power generation. The 25.9 billion cubic feet per day (Bcf/d) increase in residential and commercial consumption from last summer (2013) to last winter (2013-14) was the largest on record because of historically cold weather in much of the country east of the Rocky Mountains. The large increase in natural gas use for space heating last winter also contributed to a record-high draw in natural gas stocks. The purpose of this report is to analyze the relationship between natural gas consumption, stocks, prices, and winter weather.

Table 1. Average consumption and stock draw during summer and winter months over the last five years (April 2009 - March 2014)
(billion cubic feet per day)

	Summer (April - September) Average	Winter (October – March) Average
Residential consumption	5.5	20.5
Commercial consumption	5.0	12.2
Industrial consumption	17.9	20.5
Electric Power consumption	24.4	18.8
Working gas stock build (draw)	9.6	(10.5)

Source: U.S. Energy Information Administration, *Natural Gas Monthly*

The EIA *Short-Term Energy Outlook* (STEO) projects consumption and stock draws this winter returning to more normal levels based on projections for close-to-normal temperatures. Henry Hub spot prices are expected to average $4.00/MMBtu, 11.6% lower than the average price last winter. EIA projects higher residential and commercial prices, but lower overall heating bills in the residential and commercial sectors because of lower consumption.

Weather Trends

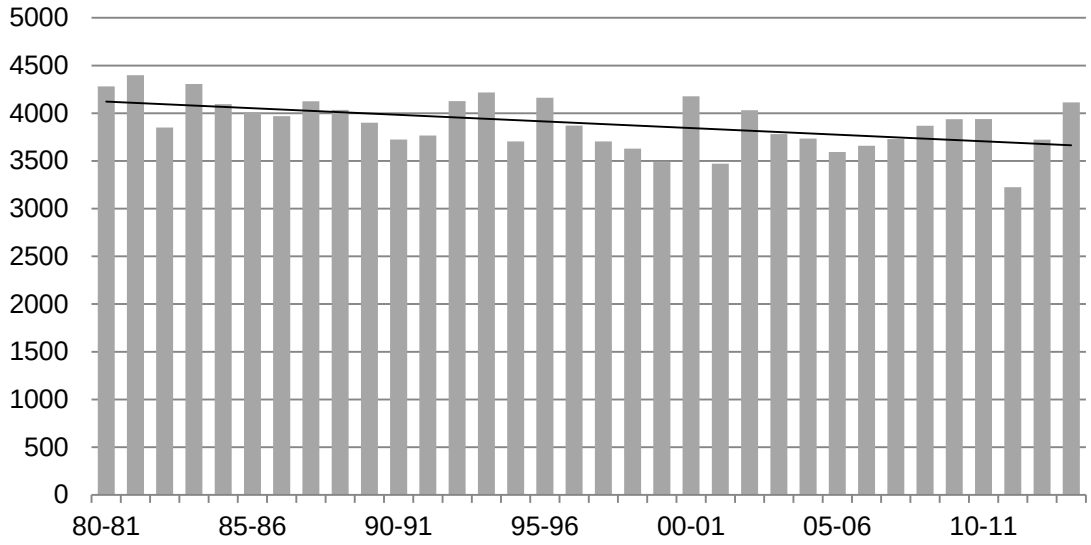
The primary indicator of the demand for natural gas for space heating is heating degree days reported by the National Oceanic and Atmospheric Administration (NOAA). Degree days are based on the assumption that when the outside temperature is 65°F, no heating or cooling is needed. Degree days are the difference between the average of the daily high and low temperatures and 65°F. If the temperature mean is above 65°F, we subtract 65 from the mean and the result is cooling degree days. If the temperature mean is below 65°F, we subtract the mean from 65 and the result is heating degree days. As a rule-of-thumb, a 1%

increase in heating degree days translates to a 1% increase in the demand for fuel for space heating.

NOAA reports heating and cooling degree days at the local, state, regional, and national levels. NOAA calculates degree days for regions and the United States by weighting state degree days using fixed population shares, which are currently from the 2010 Census. Thus, historical and forecast regional and U.S. degree days reported by NOAA reflect changes in degree days over time for a given fixed population distribution. Energy consumption, however, is a function of not just changes in temperature but also of migration of the population. EIA calculates and reports regional and U.S. degree days using current year state population (population in the same year the degree days are measured) in the STEO rather than fixed state populations (see *Short-Term Energy Outlook Supplement: Change in Regional and U.S. Degree-Day Calculation*).

EIA's winter heating degree days have followed a slightly declining trend over time because of population migration west and south and a possible warming trend (Figure 1). There have been wide variations in individual years: the winter of 2011-2012 was one of the warmest on record in the United States; while the most recent winter, which was brutally cold in some regions, averaged out to about 10% colder than the previous 10-year average.

Figure 1: U.S. Heating Degree Days, 1980-2014

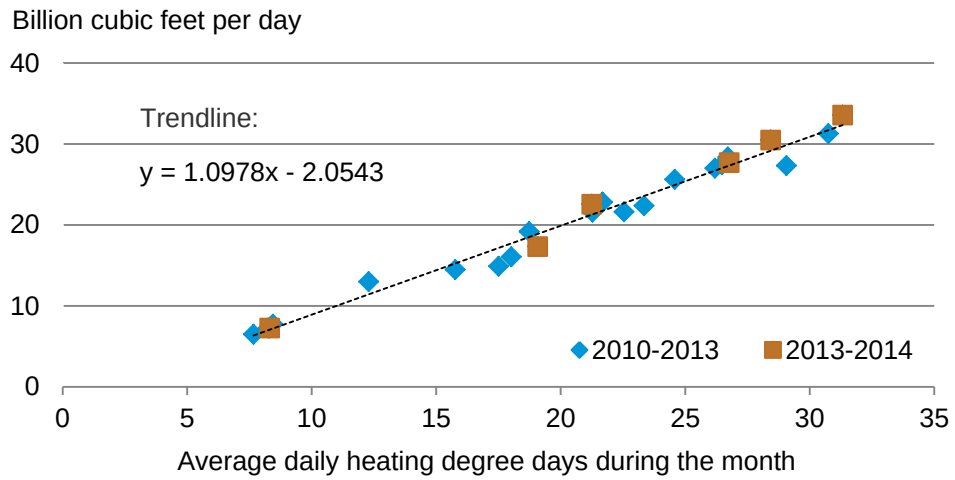


Source: National Oceanic and Atmospheric Administration
Note: Bars represent sum of October - March heating degrees for the winter season.

Sensitivity of natural gas consumption to weather

Winter natural gas consumption largely depends on heating degree days. Figures 2a and 2b show the relationships between average residential and commercial consumption during the month and average daily heating degree days (monthly HDDs divided by days in the month) over the past four winters.[1] Each point represents average daily gas consumption and average daily heating degree days in a given month, and the line of the graph approximates the relationship between the two. On average, a daily increase/decrease of 1 HDD per day corresponds to an increase/decrease in residential sector consumption of about 1.10 Bcf/d and 0.49 Bcf/d in the commercial sector.

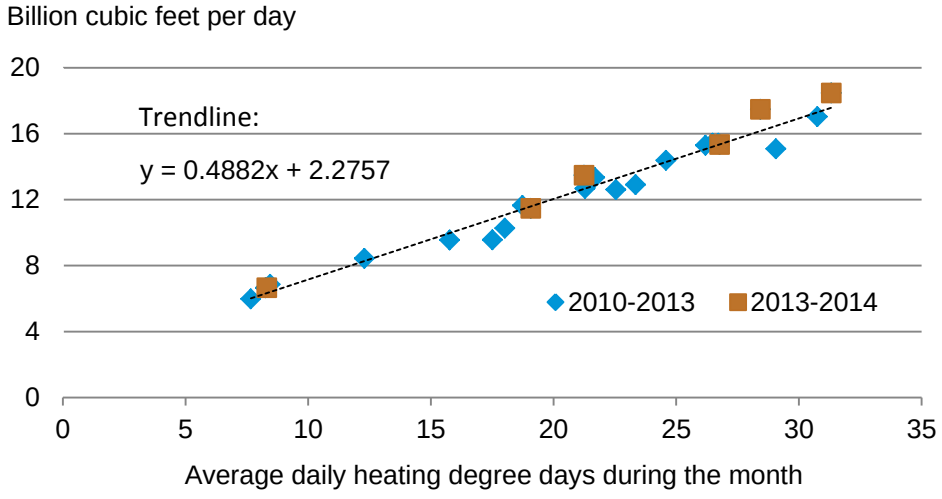
Figure 2a. U.S. monthly average residential natural gas consumption versus heating degree days, winter months 2010-2014



Source: U.S. Energy Information Administration, *Natural Gas Monthly*

[1] Because natural gas data collection methodology changed in 2010 (see "Changes in Natural Gas Monthly Consumption Data Collection and the Short-Term Energy Outlook"), the data used here only represent the four winter seasons (October – March) from winter 2010-11 through the most recent winter, 2013-14.

Figure 2b. U.S. monthly average commercial natural gas consumption versus heating degree days, winter months 2010-2014

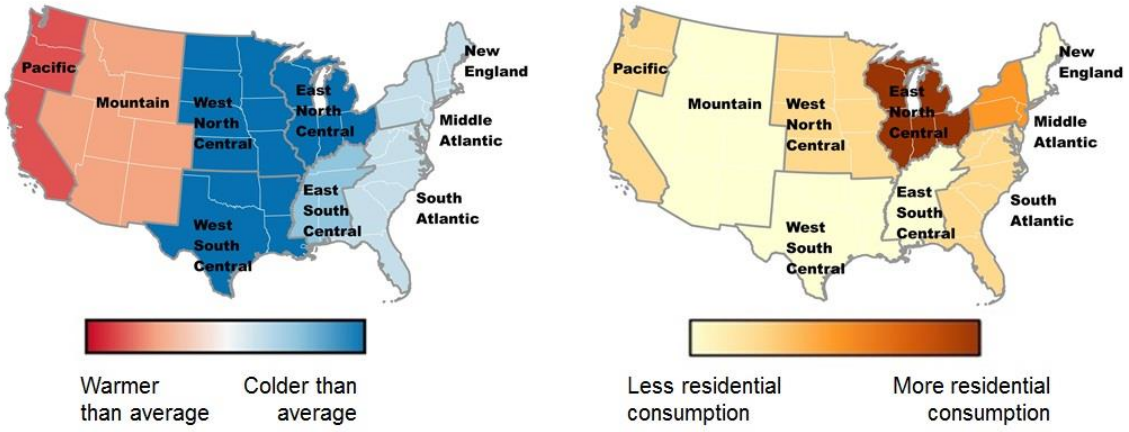


Source: U.S. Energy Information Administration, *Natural Gas Monthly*

Regional Natural Gas Markets

The East North Central Census Division (Wisconsin, Michigan, Illinois, Indiana, and Ohio) is the largest natural gas consuming division in the country, making up 28% of all residential consumption and 24% of commercial consumption in 2013. The East North Central, along with being the largest consumer of natural gas, also received some of the coldest weather this past winter. While most of the United States east of the Rockies was very cold, the cold disproportionately affected heavy natural gas users. Figure 3 shows the temperature deviation from normal and the average winter residential gas consumption. The East North Central (19.5% colder than average this past winter) and West North Central are (18.2% colder than average) are typically the coldest divisions of the country.

Figure 3. 2013-14 temperature deviation from previous 10-year average and winter 2013-14 average residential consumption



Note: Temperature map represents deviation of winter 2013-14 total heating degree days from previous 10-year average.
Source: National Oceanic and Atmospheric Administration, EIA *Natural Gas Monthly*

Table 2 shows how consumption increases on average for a daily increase of 1 heating degree day by Census division. Divisions with more households using natural gas for space heating have higher values. Since the East North Central has the largest number of households that use gas heat, the response is greatest. The response in the South Atlantic (which has about 6 million homes that heat primarily with natural gas) is close to the Pacific and Mid-Atlantic (where 10.2 and 9.4 million households, respectively, heat with natural gas). This is likely because of the amount of homes in the South Atlantic that use natural gas as a secondary heat source to a heat pump. Heat pumps work best at temperatures greater than 30 degrees Fahrenheit or so — when temperatures drop below a certain threshold, the backup heat source kicks in.

Table 2. Change in daily consumption (billion cubic feet per day) per daily increase of 1 heating degree day

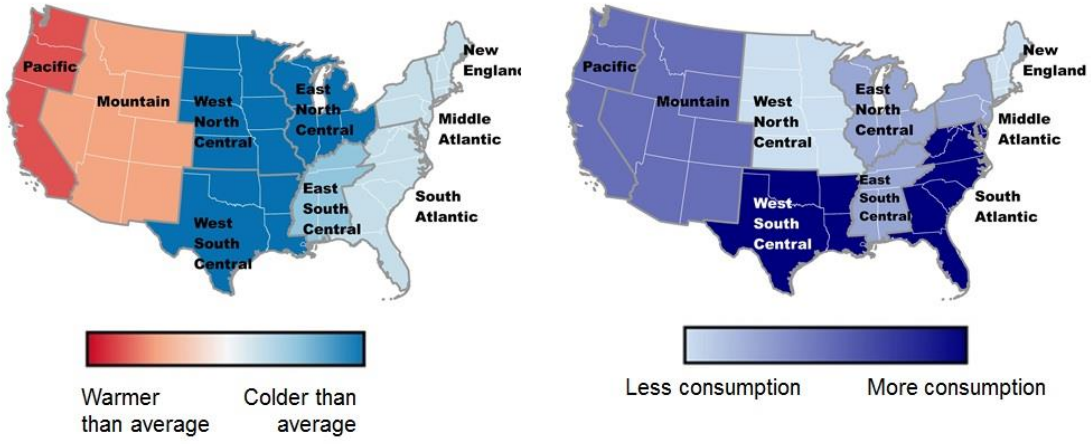
Census Division	Residential	Commercial
East North Central	0.23	0.10
East South Central	0.06	0.03
Middle Atlantic	0.17	0.08
Mountain	0.08	0.04
New England	0.04	0.03
Pacific	0.16	0.04
South Atlantic	0.16	0.07
West North Central	0.08	0.04
West South Central	0.13	0.05
U.S.	1.1	.49

Total U.S. consumers (millions)	58.30	5.36

Note: Residential consumer count represents households that use natural gas as their primary space heating fuel. Commercial consumer count represents all businesses that buy their gas from the company that delivered it to them.
Sources: Energy Information Administration, *Natural Gas Monthly*, National Oceanic and Atmospheric Administration, Census Bureau American Community Survey.

While the East North Central is dependent on natural gas for residential and commercial heating, 63% of households in the South region (East South Central, West South Central, and South Atlantic Census divisions) use electricity as their primary heating source. Much of this electricity is generated from natural gas. Texas alone accounts for about 17% of all natural gas-fired generation in the United States. Figure 4 shows the same cold-weather deviation by region as in Figure 3, but shows electric power gas consumption this past winter — the West South Central division relied primarily on electricity generated from natural gas to meet heating demand.

Figure 4. 2013-14 temperature deviation from previous 10-year average and winter 2013-14 consumption of natural gas for electric power consumption



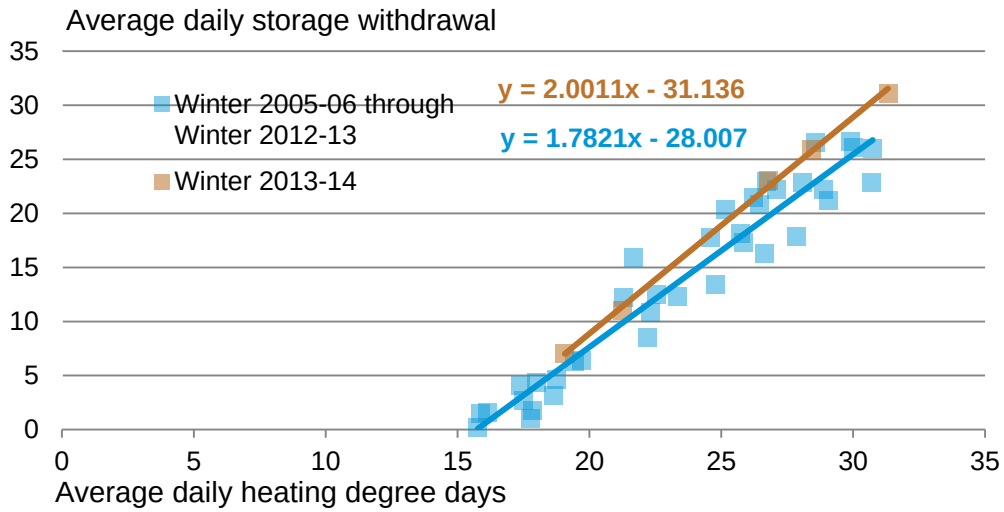
Note: Temperature map represents deviation of winter 2013-14 total heating degree days from previous 10-year average.
Source: National Oceanic and Atmospheric Administration, EIA *Natural Gas Monthly*

Storage and weather

Working natural gas in storage in the Lower 48 states dropped to 836 billion cubic feet by the end of March 2014, which was 54%, or nearly 1 trillion cubic feet, less than the previous five-year average, and the lowest level since 2003. This was largely the result of the cold weather disproportionately affecting areas with high natural gas use – both for space heating and for generating electricity.

Figure 5 shows heating degree days and storage withdrawals for months with a net withdrawal from the winter of 2005-06 through 2013-14 (usually November through March). Each point on the scatterplot represents the daily rate of stock withdrawals and average daily heating degree days for a given month. The 2013-14 heating season had record withdrawals with four of the ten largest weekly withdrawals on record. Over the last nine winters, an average daily one-degree increase in heating degree days resulted in an average 1.8 Bcf/d increase in stock withdrawals. This past winter, however, all months were above this average rate. The steeper slope on the brown line in the figure implies that more gas was withdrawn from storage per heating degree day. Instead of a 1.8 Bcf/d increase in withdrawals, withdrawals during this past winter increased on average 2.0 Bcf/d for each one-unit increase in heating degree days. These storage withdrawal rates are slightly higher than the average increases in natural gas consumption (Figures 2a and 2b) of 1.1 bcf/d in the residential sector and 0.5 Bcf/d in the commercial sector for the same increase of 1 heating degree day. The stock draw probably exceeds the average consumption increase because of demand from other sectors that use more natural gas when the weather is colder. The industrial sector uses gas directly, while consumers who heat with electric power often use electricity generated by natural gas.

Figure 5. Monthly heating degree days and stock withdrawals, winter months 2005 - 14



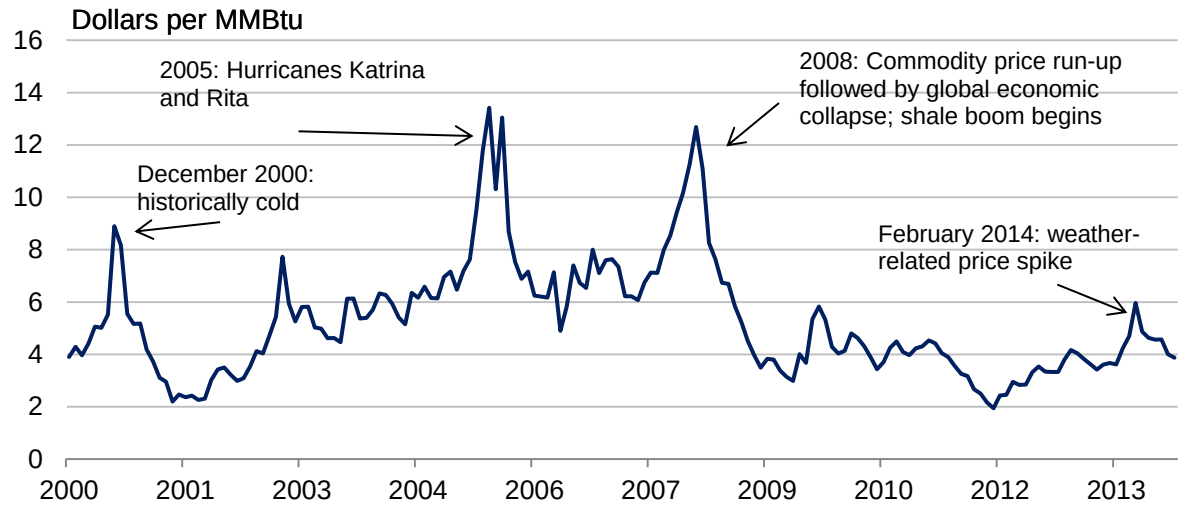
Source: National Oceanic and Atmospheric Administration, Energy Information Administration *Natural Gas Monthly*

Prices and weather

Natural gas prices fluctuate daily in response to a variety of factors, but for the most part, the price response to weather has been much more tempered in the years since the shale boom began around 2007. This past winter, however, Henry Hub prices reached six-year daily highs and Northeastern spot prices reached all-time highs. Infrastructure issues resulting from the cold weather and high demand were a key factor — several pipelines restricted capacity to avoid over-scheduling their systems by nominating more natural gas than they could deliver.

In the 2013-14 winter, Henry Hub prices spiked in February (Figure 6). The high February prices came after three months of colder-than-average weather, which drew down working gas stocks and heightened concerns about supply. While prices rose in February 2014, the increase was relatively small compared with pre-shale boom price spikes.

Figure 6. Monthly Henry Hub average spot price, 2000 - 2014

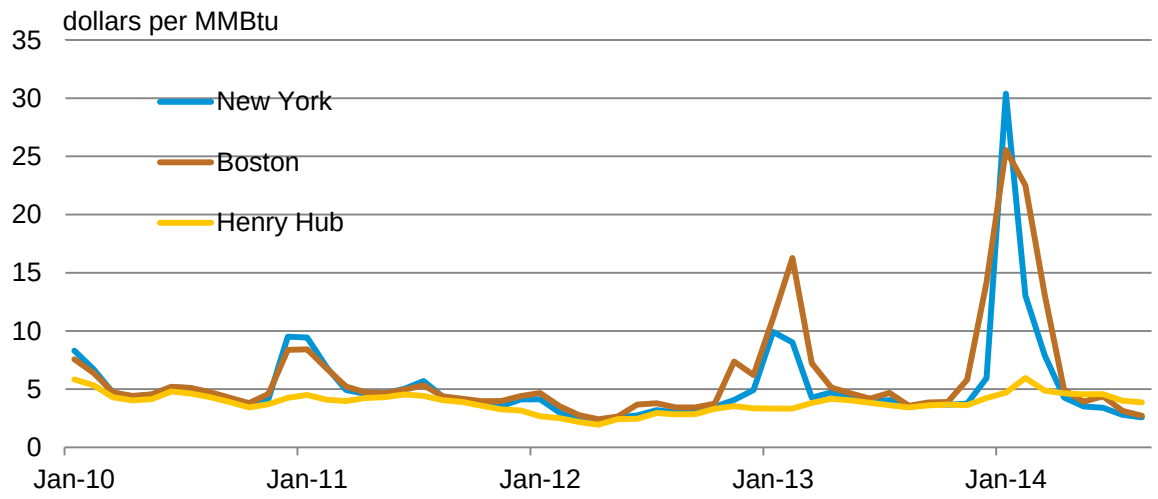


Source: Natural Gas Intelligence

The Northeast has seen large spot price spikes during very cold winters because of infrastructure constraints (Figure 7). Major pipelines delivering gas to Northeast consumers have been running at or near capacity since the start of last winter, and during January 2014, several major pipelines limited flows to some consumers to prevent system imbalances. Adding to the constraints was a force majeure (which frees both parties from upholding a contract in the event of extraordinary circumstances) on a segment of Texas Eastern's pipeline in Pennsylvania following unplanned maintenance.

As domestic production has increased over the past several years, imports of liquefied natural gas and pipeline imports from Canada have become less important. However, these sources are still important marginal sources of supply in times of high demand. In particular, this winter, cold weather curtailed production in the Marcellus, causing the Northeast to bring in more imports and rely on stored LNG.

Figure 7. Monthly spot prices, 2010 - present



Source: Natural Gas Intelligence

Changes in spot prices do not directly translate into changes in the prices residential and commercial customers pay to their local distribution company (LDC) for natural gas. LDCs begin buying gas for the upcoming winter in April, and put this gas into storage. In the winter heating season, the LDCs pull gas out of storage in addition to buying on the spot market. LDCs may lock in prices using the New York Mercantile Exchange futures contracts. Residential and commercial prices are regulated by the state regulator and rate changes may significantly lag changes in the LDC's gas purchase costs. The per-unit price the customer pays represents two major components: a fixed component, to cover the LDC's operating costs, and a variable component, representing the cost of natural gas. The per-unit price of gas is much higher in the summer because the fixed costs are spread out over a smaller volume, and the residential price usually peaks in August. Residential prices are lowest in winter because of the higher consumption volume. Consequently, colder winters can be associated with lower average residential prices. However, the increase in consumption is greater than the related decline in the average price such that average household expenditures on natural gas are higher.

Winter 2014 Forecast

The winter of 2013-14 was historically cold in some areas, and overall heating degree days in the United States were about 10% greater than the previous 10-year average. The STEO forecast is based on the NOAA weather heating degree day forecast. The latest NOAA forecast is for HDDs this winter to be close to normal, or about 10% warmer than last winter. The October STEO also reports results from two scenarios based on 10% colder-than-forecast and 10% warmer-than-forecast weather for every region in every month of the winter. Under the

baseline forecast of near-normal weather, EIA projects winter residential and commercial consumption will average 12% and 11% less than last year, respectively. Under the cold-weather scenario, residential and commercial consumption are expected to both be 4% less than last year's levels.

Natural gas working inventories fell to almost 1 Tcf below the previous 5-year (2009 –13) average at the end of March 2014. Over the past summer, stocks closed the gap to the 5-year average. As of September 26, 2014, working gas stocks were 399 Bcf below the 5-year average, due in part to growth in natural gas production and mild summer weather. EIA projects working gas inventories at the end of March 2015 at 1,534 Bcf, about 122 Bcf less than the previous five-year (2010-2014) average.

EIA projects strong growth seen in 2014 production will continue, with marketed production this winter averaging 75.3 Bcf/d, compared to 71.8 Bcf/d last winter. The growth in production implies that even if the upcoming winter was as cold as last winter there would be a smaller storage withdrawal than last winter.

This year's Winter Fuels Outlook projects that residential and commercial prices will be higher than they were last year, largely because through 2014 (when utilities began buying gas) prices have averaged higher than year-ago levels, and are currently higher than year-ago levels. A 10% colder winter would imply higher residential prices, as utilities would buy more gas on the spot market to meet demand. Table 3 shows the baseline and cold-weather scenarios for the 2014-15 winter.

Table 3. Winter (Oct. 2014 - Mar. 2015 baseline and cold weather scenarios

	Baseline	10% Colder Scenario
Residential consumption (Bcf/d)	20.25	22.08
Commercial consumption (Bcf/d)	12.33	13.11
Residential price ($/Mcf)	$10.42	$10.74
Commercial price ($/Mcf)	$9.02	$9.48
Working gas in storage (Bcf)	1,534	1,073
East	598	412
West	290	248
Producing	646	413

Source: U.S. Energy Information Administration, *Short-Term Energy Outlook*, October 2014