UNDERSTANDING
NATURAL GAS MARKETS

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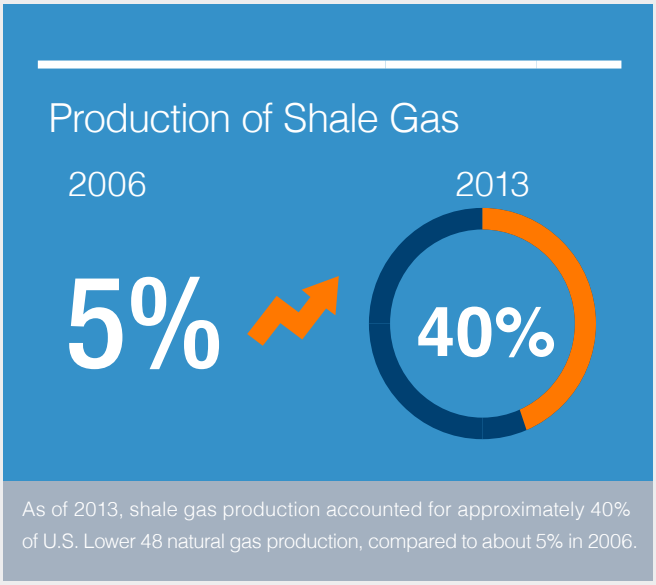
Overview

Natural Gas is an Important Source of Energy for the United States.

Natural gas is an attractive fuel because it is clean burning and efficient, and ample supplies of natural gas are available from domestic resources. Recently, natural gas production in the U.S. has increased substantially due to technological advancements in natural gas extraction methods. This increased production has displaced traditional supply sources and resulted in reduced prices for natural gas consumers. The prospect of ample natural gas supplies, continued low prices, and the favorable environmental and economic position of natural gas-fired electric generation plants are leading to expectations of growing U.S. demand for natural gas, especially in the electric and industrial sectors, and potentially for export as *liquefied natural gas*[1] (LNG).

The increases in U.S. natural gas production have come from *unconventional* shale gas resources, which have become more accessible and economic due to advancements in *horizontal drilling* and *hydraulic fracturing*. These technological advancements have resulted in domestic production growth that has exceeded even the most optimistic forecasts of natural gas production from a decade ago (see **Figure 1**). As of 2013, shale gas production accounted for approximately 40% of U.S. Lower 48 natural gas production, compared to about 5% in 2006. This unexpected production growth has led to major changes in the landscape of the U.S. natural gas industry. The important trends now affecting the industry include the following:



As of 2013, shale gas production accounted for approximately 40% of U.S. Lower 48 natural gas production, compared to about 5% in 2006.

- U.S. natural gas demand is increasingly served by domestic production from unconventional shale gas sources rather than imported natural gas from Canada and other conventional

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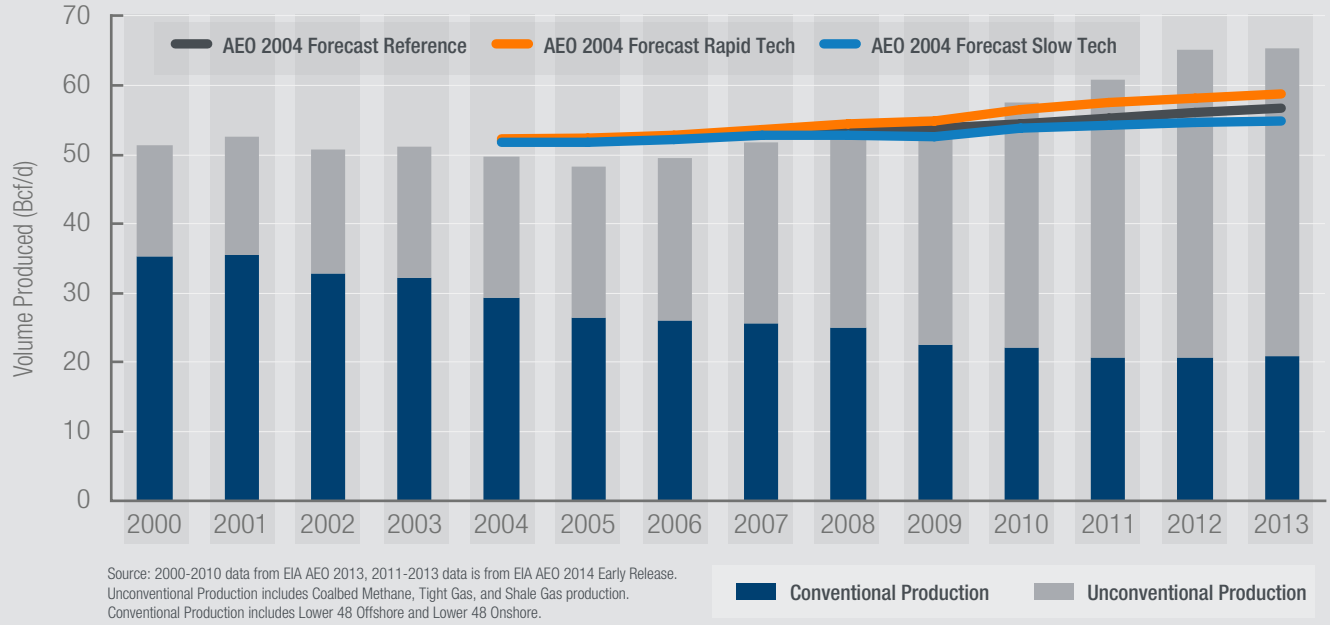

Source: 2000-2010 data from EIA AEO 2013, 2011-2013 data is from EIA AEO 2014 Early Release.
Unconventional Production includes Coalbed Methane, Tight Gas, and Shale Gas production.
Conventional Production includes Lower 48 Offshore and Lower 48 Onshore.

supplies. The technological advancements that have led to growing shale gas production were spurred, in part, by the high natural gas prices that existed during much of the last decade.

- Natural gas use for electricity generation is poised to increase due to low natural gas prices and expectations that coal-fired power plants will continue to be retired due to environmental regulations. Low natural gas prices are also expected to drive demand growth in the industrial sector.
- The growth in shale gas production has resulted in shifting flows on the U.S. interstate pipeline network. In particular, Marcellus shale production in Pennsylvania and West Virginia is in relatively close proximity to the major east coast consuming markets. This is reducing the need for long-haul pipeline transportation from traditional supply areas while at the same time increasing the need for local pipeline infrastructure to support the new production.
- The substantial production increases, and low prices in the U.S. relative to overseas, are leading to the development of both LNG and pipeline export projects. These projects could result in the U.S. becoming a net exporter of natural gas[2], whereas historically the U.S. was a net importer due to its reliance on Canadian natural gas supplies in meeting domestic consumption.

The shale gas revolution has led to U.S. natural gas supply growth that has exceeded demand growth. As a result, Canadian imports and other conventional supplies have been displaced, prices have fallen substantially and price volatility has declined to some extent (see **Figure 2**). The current environment is a considerable change from the tight supply-demand balance that characterized U.S. natural gas markets for much of last decade, and led to natural gas price spikes in several periods during 2000-2008. The last large price spike in the summer of 2008 gave way to a substantial price decline as shale gas production increased and the economic recession brought on by the global financial crisis decreased the demand for natural gas. While demand has increased since 2009, domestic shale production has increased even faster. The result has been relatively low prices over the past several years, but not as low as the prices experienced during most of the 1990s.

This brochure examines these trends in more detail and describes some of the key changes that will affect U.S. natural gas markets and prices in the coming years, including expectations for natural gas demand growth in the electric and industrial sectors and the prospects for LNG exports from the U.S. to overseas markets.

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NYMEX NATURAL GAS 12-MONTH AVERAGE FUTURE PRICES (April 1990-December 2013)

Year	12-Month Average	Standard Deviation
1990–1999	$2.04	0.32
2000–2008	$6.45	2.45
2009–2013	$4.32	0.80

Source: Bloomberg.

The North American Natural Gas Marketplace

The U.S. relies on natural gas as an important part of its energy portfolio.

Natural gas provides 27% of the marketable energy consumed in the United States.[3] Oil products and coal are the other two major sources of energy. Natural gas is a valued source of energy because it is versatile and burns cleanly. As a result, natural gas use is commonplace in applications including cooking, residential and commercial heating, industrial process feed stocks, and electricity generation.

Physical Structure of the U.S. Natural Gas Industry

Figure 3 is a schematic illustration of the physical structure of the natural gas industry and illustrates the principal activities required to supply gas to consumers. The primary activities are:

Exploration and Production

Exploration and production include finding and developing natural gas by drilling wells, and ultimately producing gas from natural gas fields or gas that is produced in association with crude oil.

Processing

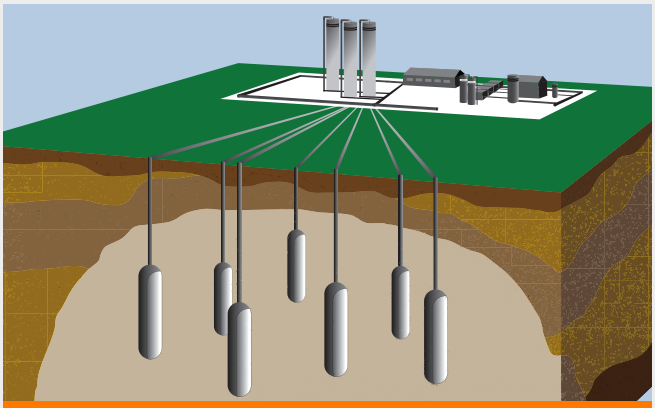
Natural gas processing removes impurities and separates higher-valued products (known as *natural gas liquids* or NGLs) that are sold in separate markets. Processing prepares a *dry gas* stream that meets industry standards for transportation in high-pressure pipelines. Pipeline companies require that the natural gas provided at the inlet of their pipelines conforms to certain quality specifications in order for it to be transported on their systems. Only natural gas that meets these specifications is transported on the extensive North American pipeline grid.

Transportation

Natural gas is transported in high-pressure pipelines from producing areas to local distribution companies, storage areas, industrial end users, and electricity generation facilities.

Storage

The natural gas production and delivery system is not designed to produce and transport the entire amount of natural gas consumers want during periods of peak demand. In order to meet peak demand, large customers and distribution companies inject gas into underground storage located near final consumers. The stored gas is withdrawn to meet consumers' needs during times of peak demand, such as a cold winter day. There is also a substantial amount of storage in producing areas, which allows producers to maintain constant production and helps balance supply and demand.



Underground Storage in Salt Caverns

Local Distribution

Local distribution companies own and operate the network of pipes that carry natural gas from high-pressure trunk lines to final consumers. These consumers include residential, commercial, electric generation, and industrial customers, although large electric generators and industrial customers frequently take service directly from a pipeline rather than from a local distribution company.

Liquefied Natural Gas

Imports of LNG have never been a large part of the U.S. natural gas supply, but in the 2000's when natural gas was perceived to be in short supply and prices were high, LNG import quantities grew and several new large-scale LNG import terminals were constructed. Due to the rise in shale gas production and the fall in natural gas prices, many of these new import facilities have generally been unutilized.

The U.S. currently imports less than one percent of its natural gas in the form of LNG (compared to a peak of three percent in 2007) primarily from the Everett terminal near Boston and the Elba Island

PHYSICAL FLOW OF NATURAL GAS

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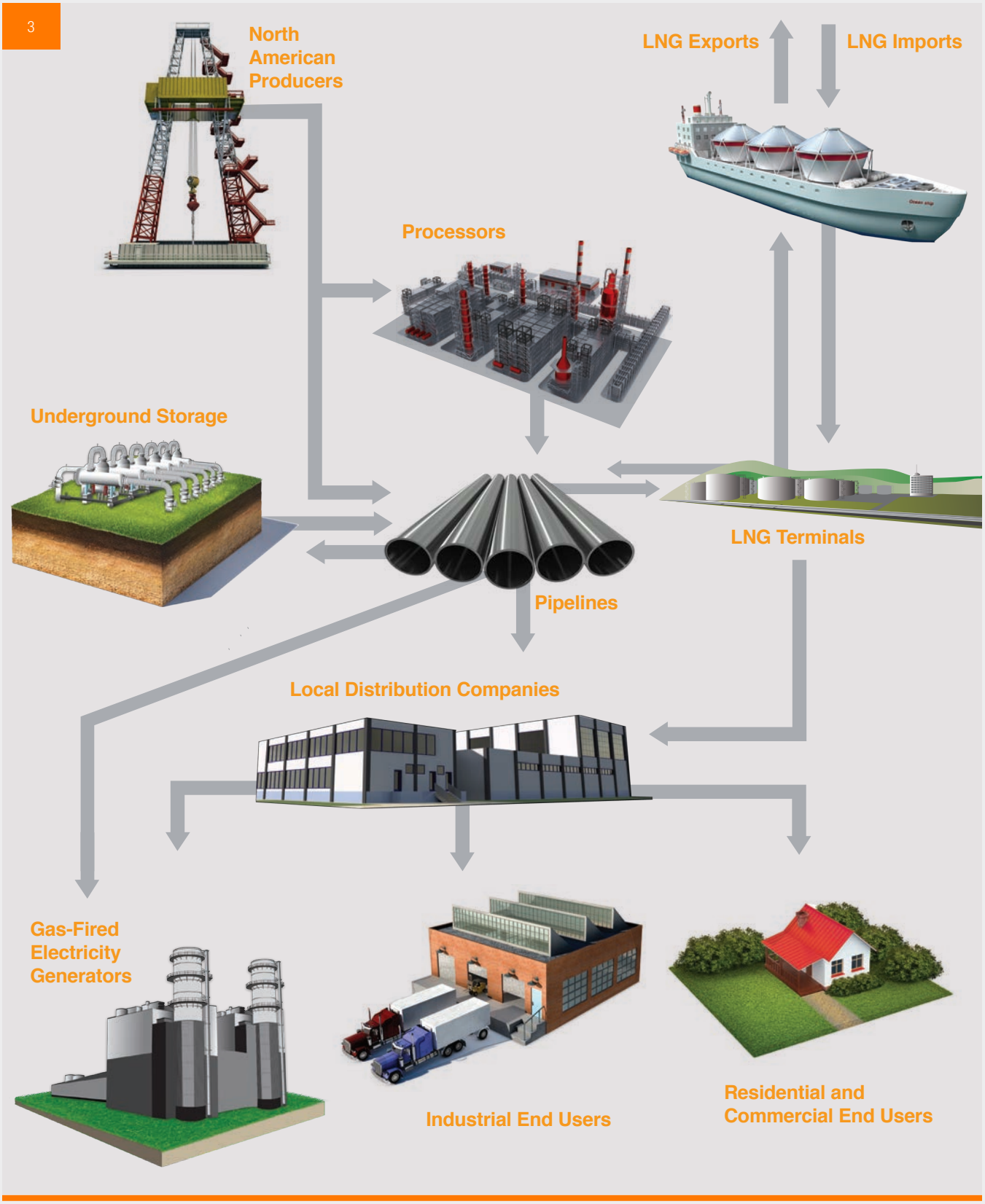


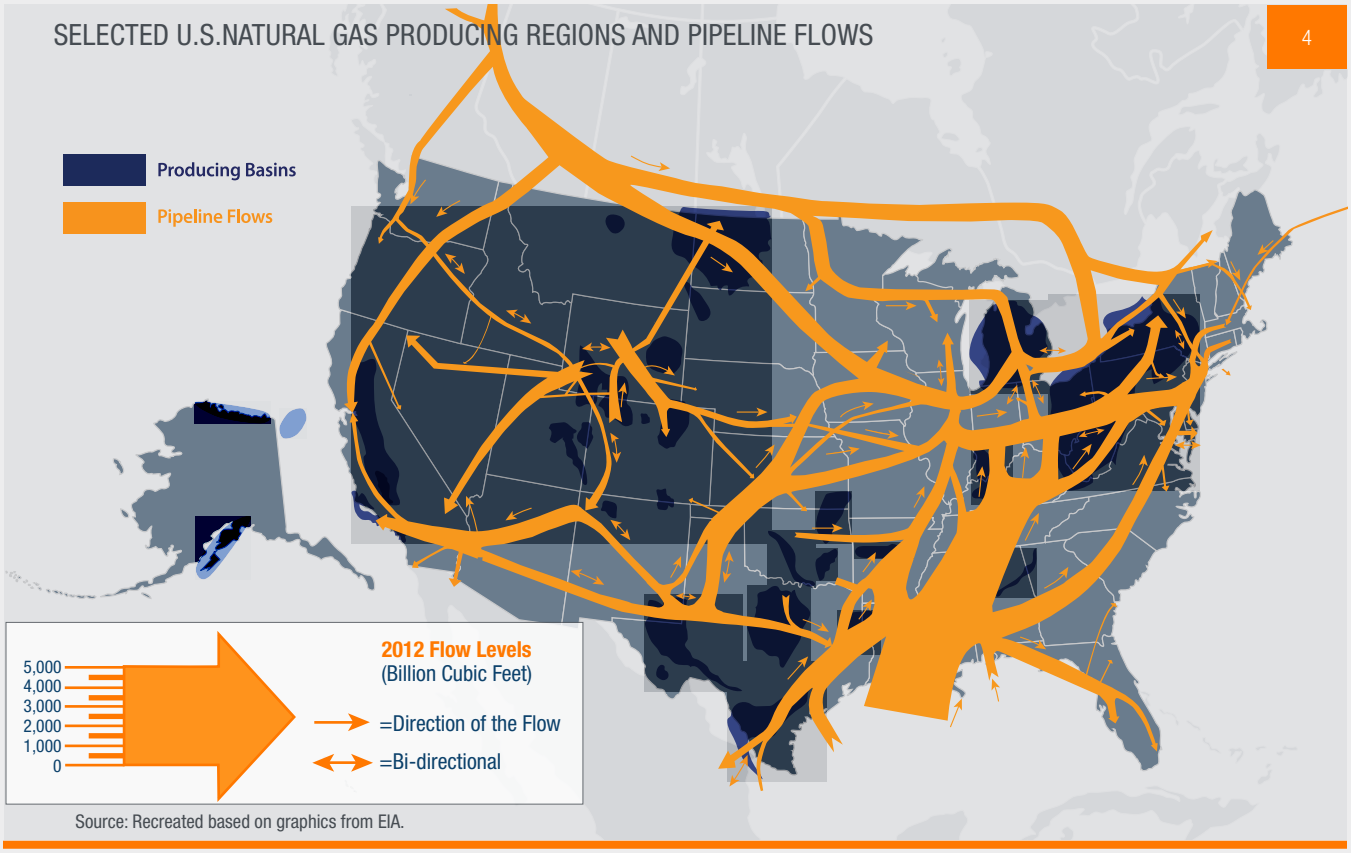
terminal in Georgia, two of eleven existing U.S. LNG import terminals. The growth in shale gas production in the U.S. has resulted in proposals to develop LNG export terminals to liquefy and ship natural gas produced in the U.S. to overseas markets. One such terminal is now under construction in Louisiana and many other liquefaction terminals have been proposed. Some of the uncertainties regarding LNG export projects are discussed in a later section.

Figure 4 shows some of the primary areas where natural gas is produced in the United States. As the figure indicates, natural gas is found in a large number of states. Major onshore production areas include the Rocky Mountains, Texas and the Gulf coast, and Appalachia. In addition, significant but declining amounts of natural gas are produced from offshore areas in the Gulf of Mexico.

While **Figure 4** shows the major flow patterns of natural gas in the U.S., these flow patterns have been changing and are expected to continue to change as a result of the development of shale gas supplies. For example, the development of substantial Marcellus shale supplies in the Appalachian region is making the region less dependent on long-haul flows of natural gas from Canada and the Gulf Coast, and is likely to result in natural gas flows from the U.S. northeast into other regions such as the U.S. Midwest and Southeast and Ontario, Canada.

The growing Marcellus supplies have required substantial investment in new pipeline infrastructure to allow these supplies to be delivered into the Northeast U.S. pipeline grid. At the same time, other pipelines that provided long-haul transportation of natural gas supplies from traditional supply areas, such as Canada and the Gulf Coast, have become less utilized as the region shifts to consuming local Marcellus natural gas production.

Natural Gas Tanker



Source: Recreated based on graphics from EIA.

As shown in **Figure 5**, some areas are subject to access restrictions that make some of the U.S. natural gas resource base (approximately 96 TCF) unavailable for exploration, including offshore areas in the lower 48 and the Alaskan Peninsula.[4]

Once natural gas is produced and processed, it is injected into pipelines for transmission to end-use customers and local distribution companies. Transmission and distribution costs are a significant portion of the total cost of delivered natural gas. The rates charged by both natural gas pipelines and local distribution companies are regulated at the federal and state level.

In recent years, the cost of the natural gas itself has decreased from 59% in 2007-2008 to 28% in 2011-2012 of the delivered natural gas cost paid by residential consumers during the heating season (November through March), while transmission and distribution charges have increased from 41% to 72% of the consumer's average heating season cost (see **Figure 6**).

Off-Shore

OFFSHORE UNDISCOVERED TECHNICALLY RECOVERABLE FEDERAL OIL AND NATURAL GAS RESOURCES MAP

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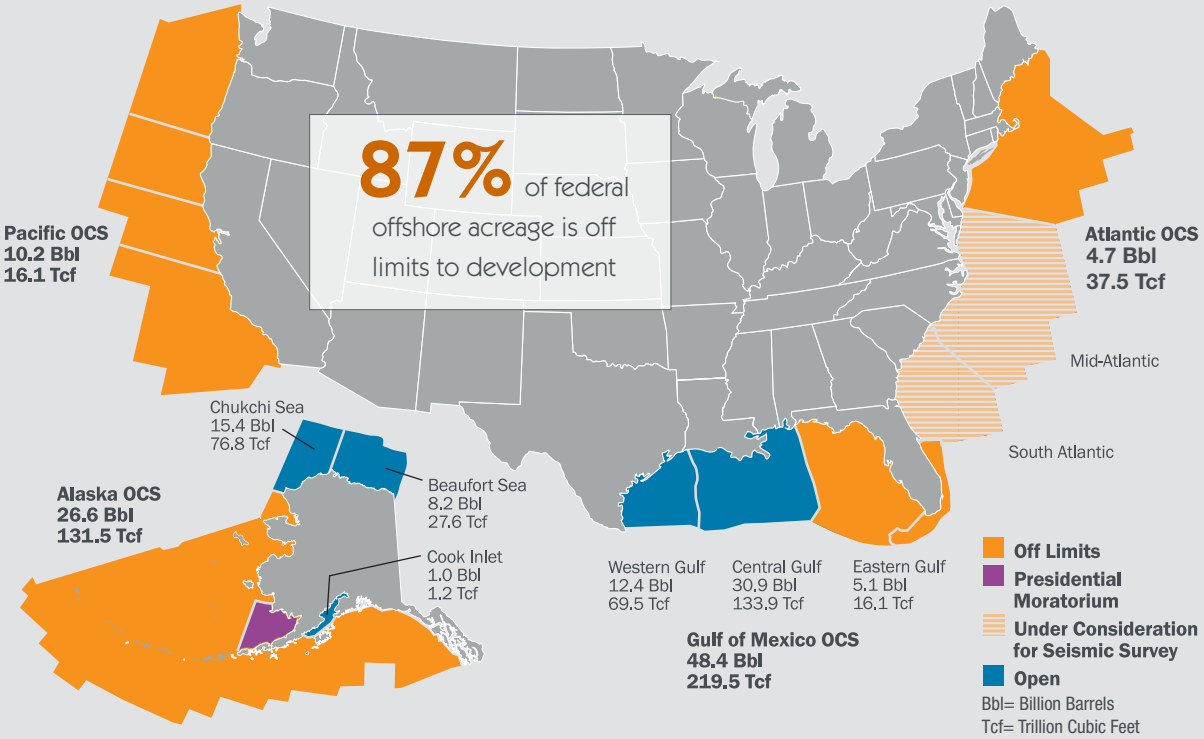

Source: API primer "Offshore Access to Oil and Natural Gas Resources," July 2014.

Natural Gas Supply

The overall size of the U.S. natural gas resource base has recently been reevaluated upward, and annual natural gas production has increased substantially, as a result of the identification and development of shale gas supplies. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas.[5] *Technically recoverable natural gas resources* in the U.S. have been estimated at 2,431 Tcf currently, compared to 1,594 Tcf in 2005,[6] with much of the increase due to increased estimates in the amount of shale gas resources. Likewise, annual U.S. Lower 48 natural gas production increased from 48.2 Bcf/d in 2005 to 65.0 Bcf/d in 2012, or 35%, primarily as a result of the development of natural gas from shale formations. **Figure 7** shows the substantial growth in annual shale gas production from less than 5 Bcf/d in early 2007 to nearly 30 Bcf/d more recently. Shale gas now accounts for over 40% of total U.S. Lower 48 natural gas production. The largest shale production is from the Marcellus (35%), Haynesville (12%), Barnett (14%), and Eagle Ford (12%) shale formations (with all other shales combining to total roughly 27%).

Figure 8 shows U.S. Lower 48 production of natural gas by source, with shale gas accounting for a significantly increasing proportion of total U.S. Lower 48 natural gas production. Shale gas production is projected to account for over 50% of U.S. Lower 48 natural gas production by 2040, and gas produced by hydraulic fracturing (including shale gas and tight gas) will account for nearly 80% of natural gas production in the future. Other supply sources are projected to decline in the coming years, with the largest reduction in conventional onshore sources not produced in association with oil.

The technological advancements—horizontal drilling and hydraulic fracturing—that have resulted in substantial shale gas production have also changed the historical relationship between the number of natural gas-directed *drilling rigs* in operation and the volume of natural gas production. As a result of these advancements, total natural gas production has continued to grow even as rigs

Processing Plant

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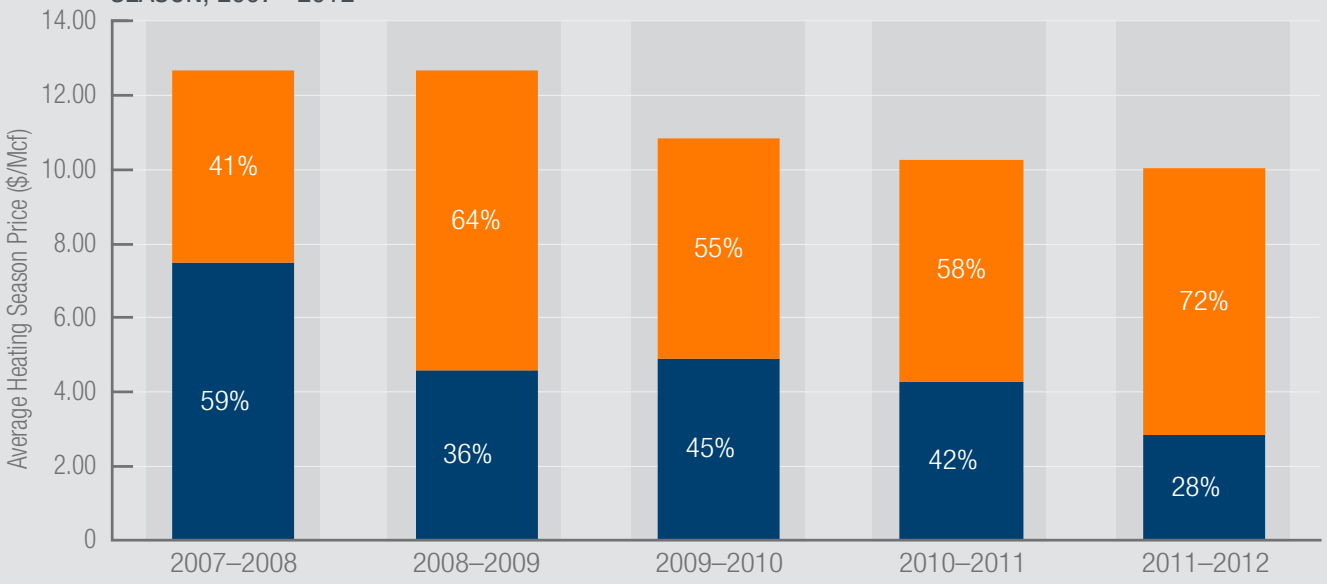
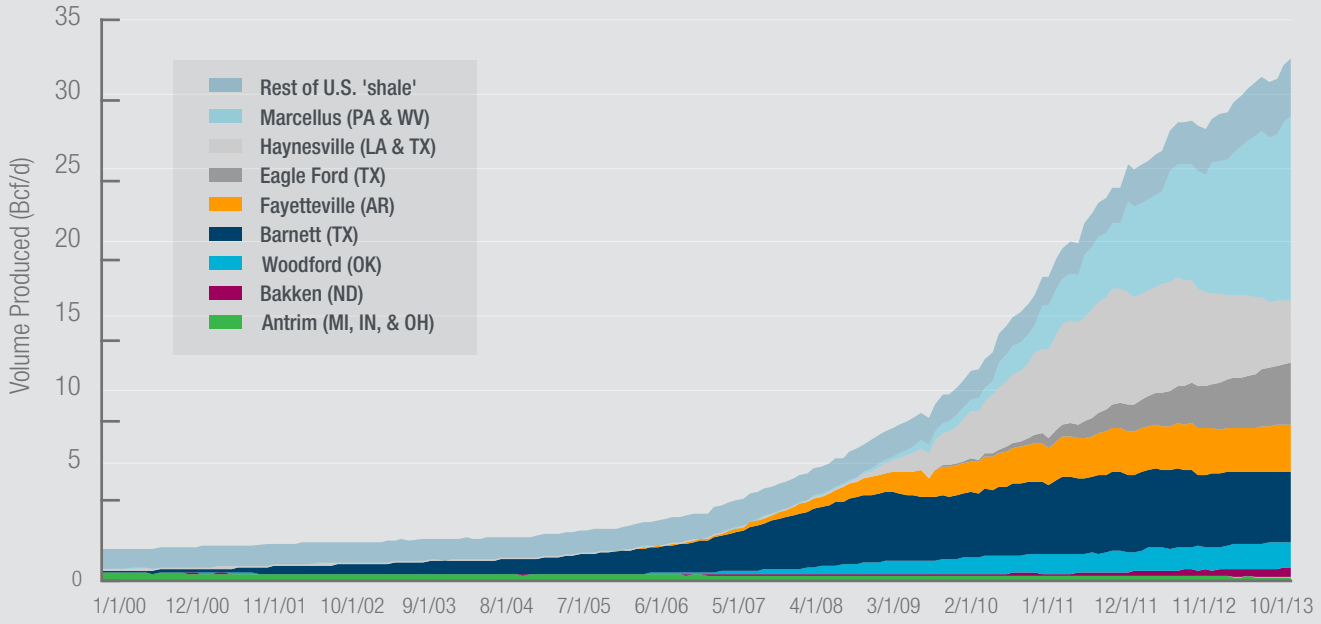
BREAKDOWN OF NATURAL GAS PRICE PAID BY RESIDENTIAL CONSUMERS DURING THE HEATING SEASON, 2007– 2012



Source: EIA. Heating season is defined as November - March. Transmission & Distribution Cost is calculated as the U.S.Price of Natural Gas Delivered to Residential Consumers minus the U.S. Natural Gas Wellhead Price.

7

MONTHLY DRY SHALE GAS PRODUCTION BY PLAY, JANUARY 2000–DECEMBER 2013 (Bcf/d)



Source: EIA - Natural gas Weekly Update for week ending January 29, 2014.

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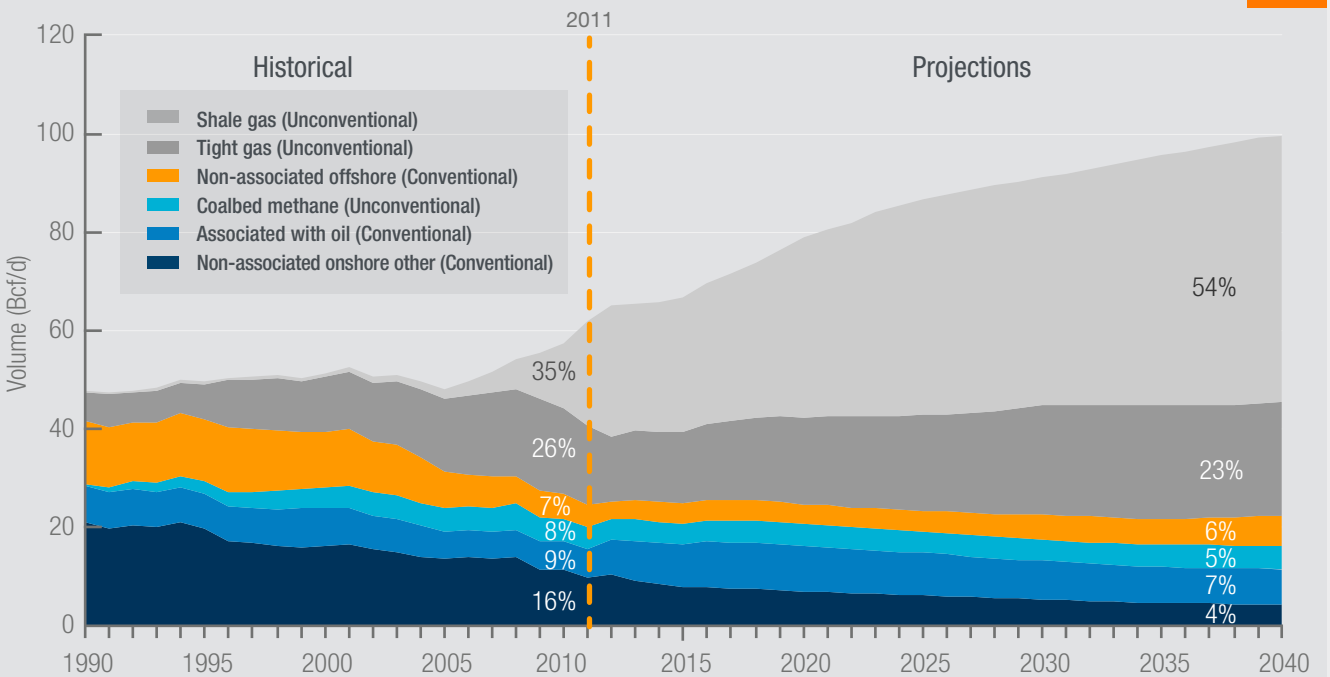
LOWER 48 DRY NATURAL GAS PRODUCTION



Source: 1990-2011 data from EIA AEO 2013, 2012-2040 data from EIA AEO 2014 Early Release. The percentages above are calculated as the percent of total Lower 48 natural gas production. Percentages may not equal 100% due to rounding.

increasingly have been directed towards oil drilling and away from natural gas (see **Figure 9**). Moreover, an increasing number of wells are producing both oil and natural gas.[7] These changes are leading to new metrics for evaluating drilling and production activity, including region-specific statistics regarding rig efficiency, new well productivity, and decline rates of existing wells.[8]

An important factor that affects drilling activity in the U.S. is the price of natural gas liquids (NGLs) that are produced in some areas as a byproduct of natural gas production. NGLs include products such as ethane, propane, butane, and isobutane, and natural gasoline or condensate. These areas may be referred to as "liquids rich" or "wet gas" plays. NGLs are removed from the natural gas stream at natural gas processing and fractionation plants and sold separately. High NGL prices (which typically have followed the trends in oil rather than natural gas prices) make it profitable to separate NGLs from natural gas and sell them as a separate product. Recent NGL prices have been high relative to natural gas prices (see **Figure 10**), which has provided a strong incentive for producers to shift their focus from dry gas plays to liquids-rich gas plays. The additional natural gas produced in highly-profitable liquids-rich plays has helped keep the price of natural gas low.

Figure 11 shows the changing nature of the U.S. natural gas supply mix. Historically, U.S. natural gas consumption exceeded production, and the difference was made up by natural gas imports by pipeline from Canada as well as a relatively small amount of LNG imports from overseas locations. With the growth in domestic shale gas supplies, imports have been declining and forecasts indicate that the U.S. will become a net exporter of natural gas later this decade.

These exports will likely include pipeline exports to Mexico, and exports in the form of LNG. Net imports from Canada are likely to continue, but at substantially lower levels than in the past (see **Figure 12**).

Drilling Rig

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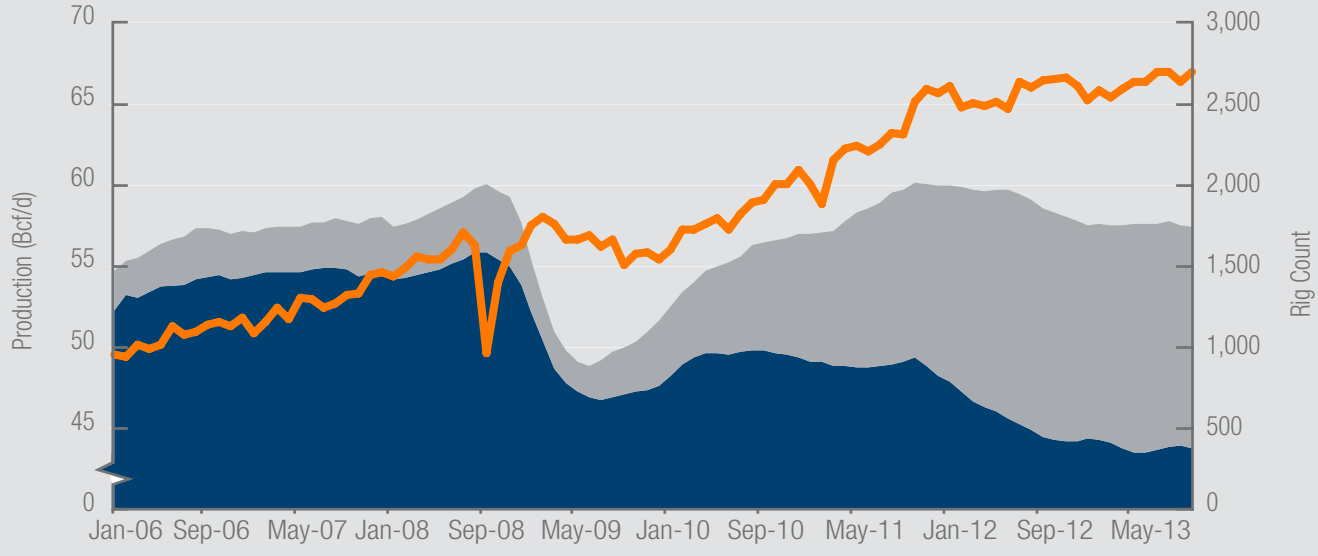
U.S. NATURAL GAS PRODUCTION AND COUNT OF OPERATING NATURAL GAS RIGS
JANUARY 2006–OCTOBER 2013



Source: EIA.

HENRY HUB NATURAL GAS PRICE VS. NGL COMPOSITE PRICE, JANUARY 2009-OCTOBER 2013

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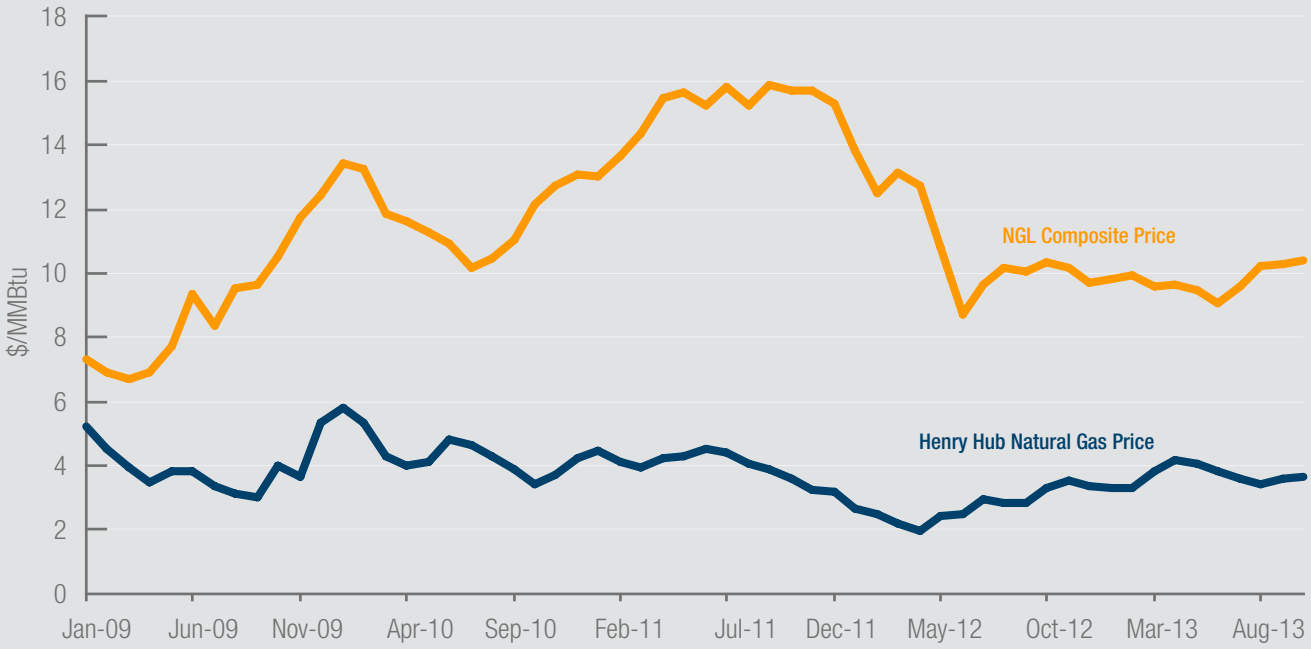

Source: EIA. The composite price is calculated by EIA as daily Bloomberg spot price data for natural gas liquids at Mont Belvieu, Texas, weighted by gas processing plant production volumes of each product as reported on Form EIA-816,"Monthly Natural Gas Liquids Report."

TOTAL U.S. GAS PRODUCTION, CONSUMPTION, AND NET IMPORTS

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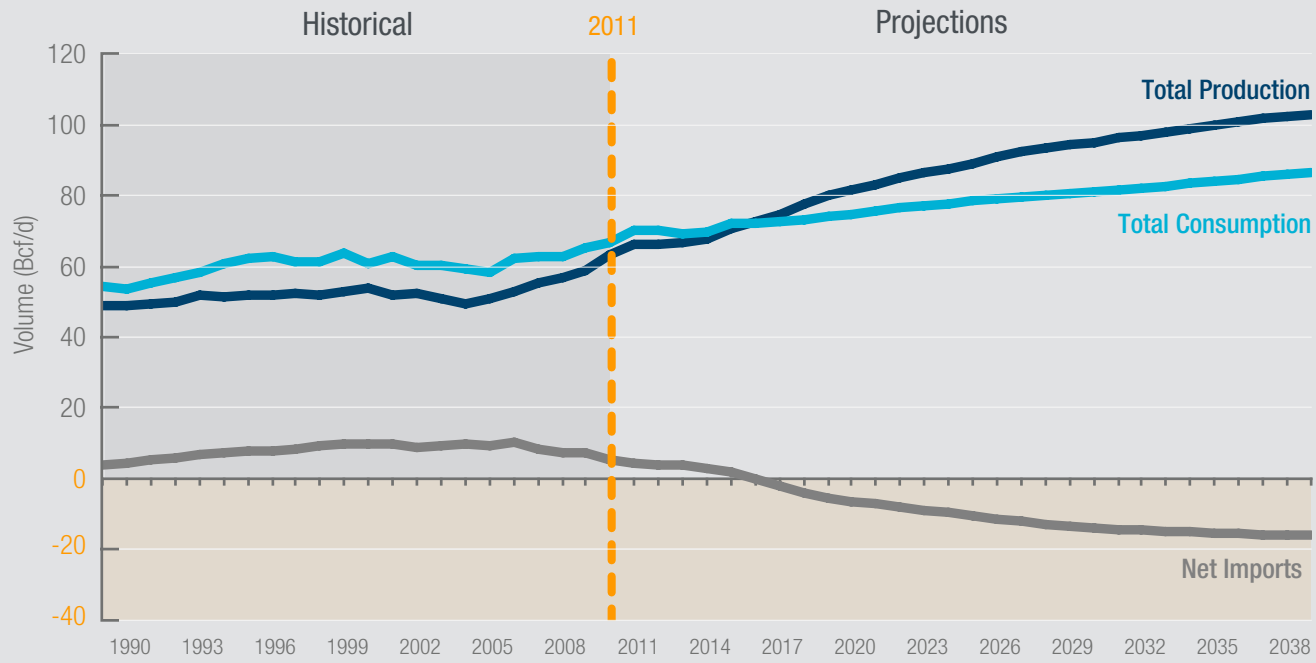


Source: 1990–2011 data from EIA AEO 2013, 2012–2040 data from EIA AEO 2014 Early Release.

Natural Gas Demand

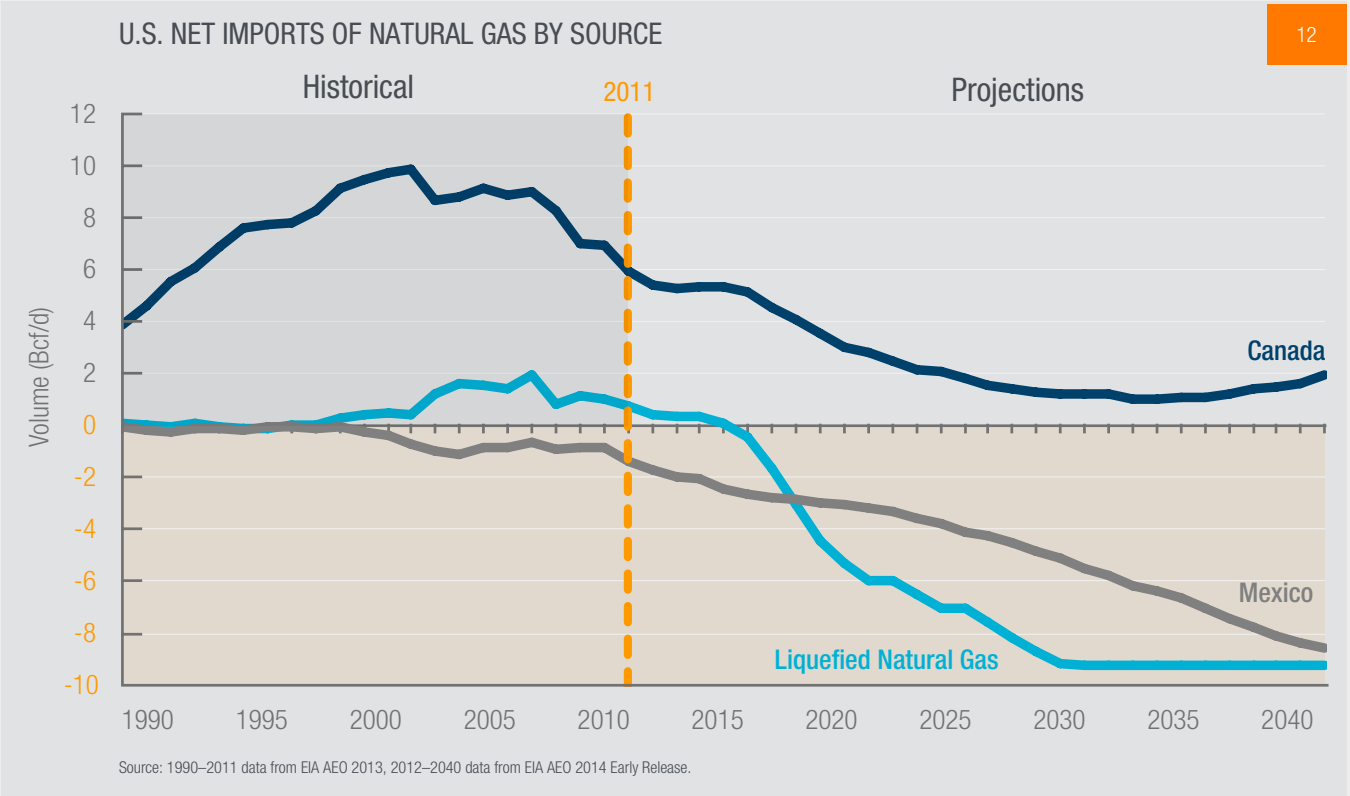
Recent declines in natural gas prices are also explained by the fact that the demand for natural gas has not grown as rapidly as the growth in supplies.

Figure 13 shows the consumption of natural gas by sector since 2000. As shown, overall consumption was flat or declining between 2000 and 2006, with some demand growth occurring in the 2007-2013 period. Residential and commercial use of natural gas has been relatively steady over the 2000-2013 period, with growth in the number of customers being offset by declining natural gas usage per customer. Industrial natural gas demand generally declined during the 2000-2009 period in response to high and volatile gas prices, while natural gas demand for power generation increased during this period, offsetting the declines in industrial demand. Since 2009, gas demand has grown in both the industrial and electric sectors. In aggregate since 2000, demand growth has been outpaced by the volume of new natural gas production that has come on line.

In 2012, natural gas use for power generation surged as a result of low natural gas prices. Low prices caused natural gas-fired electricity generating facilities to run more often and in some cases ahead of coal-fired plants. Coal and natural gas-fired generation competes to serve load in many regions of the country, and the relative prices for coal and natural gas can affect the dispatch order of electric generation facilities, and hence, electric sector demand for natural gas.

More than 65 million U.S. households use natural gas for water heating, space heating, or cooking.[9] In total, natural gas accounts for more than 50% of the fuel used to heat U.S. homes.[10] Residential and commercial heating demand for natural gas is highly weather-sensitive, making weather the biggest driver of natural gas demand in the short term. As a result, natural gas demand is highly "seasonal" in nature, with significant "peaks" in the winter heating season, as illustrated in **Figure 14**. Natural gas pipelines and distribution companies must plan to meet customers' needs during the peak demand periods. The seasonal nature of heating demand can cause the price of natural gas to vary widely at different times of the year.

As described below, the natural gas production and transmission system is not designed to fully satisfy demand during peak periods. In order to meet high seasonal winter demand for natural gas, a significant amount (ten percent or more of our annual consumption) is put into storage during periods of warm weather and lower demand. **Figure 14** shows the pattern of natural gas production and storage. The relatively flat light blue line shows natural gas



Source: 1990–2011 data from EIA AEO 2013, 2012–2040 data from EIA AEO 2014 Early Release.

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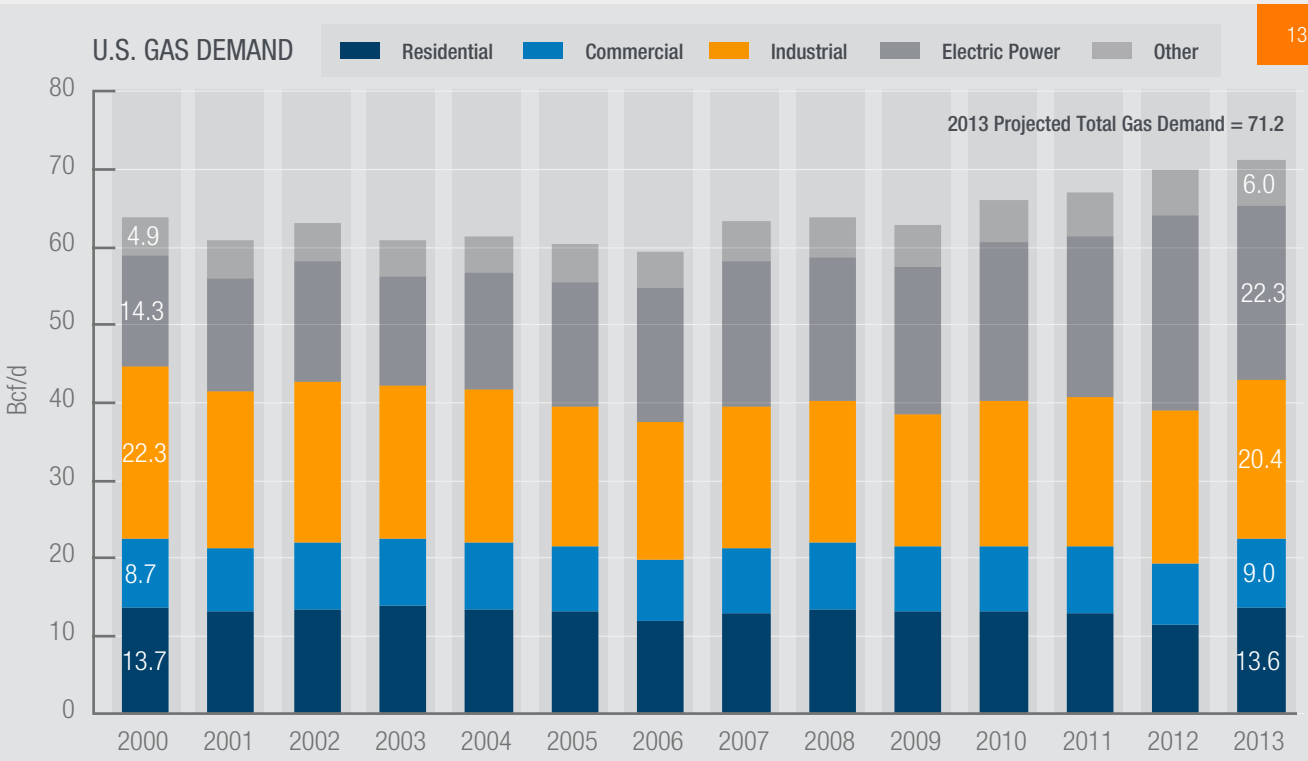
U.S. GAS DEMAND



Source: EIA. 2013 data from EIA's January 2014 Short Term Energy Outlook.

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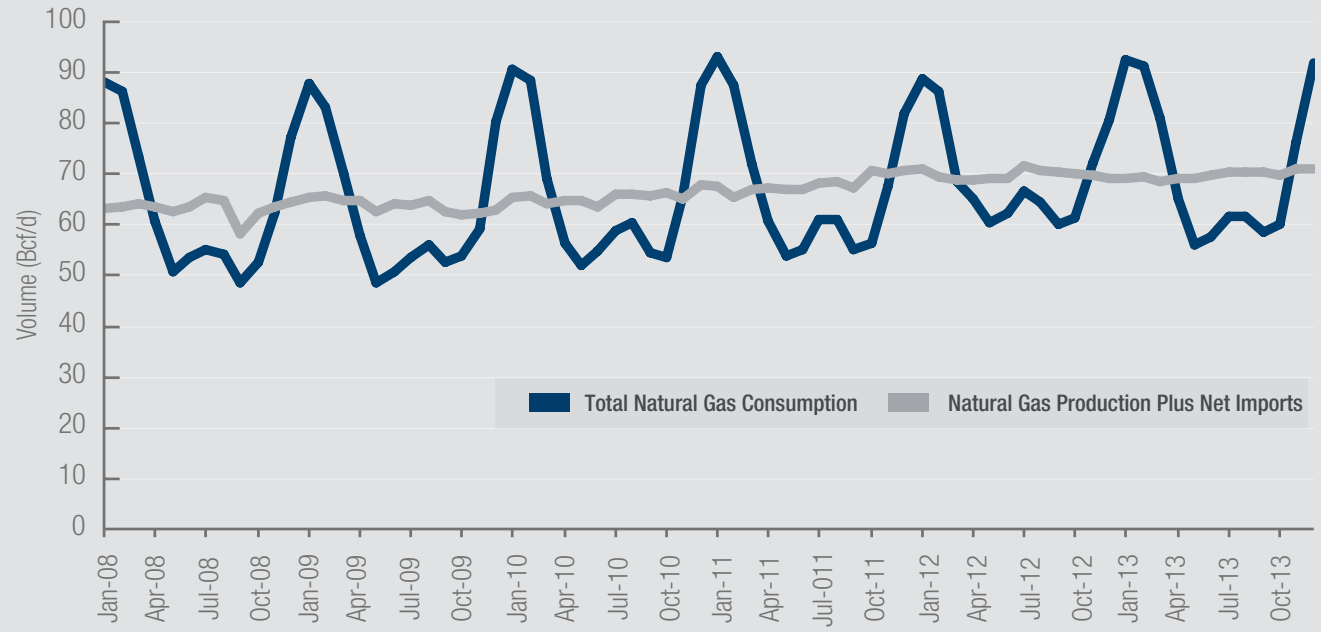
U.S. NATURAL GAS STORAGE ACTIVITY, JANUARY 2008-DECEMBER 2013



Source: EIA. November and December 2013 data from the EIA STEO January 2014 report.
Net imports is calculated as imports minus exports.

production and imports into the United States. The figure shows production remains essentially flat throughout the year, but, as the darker blue line shows, consumption rises dramatically in the winter and falls in the spring through the early fall.

Heating demand for natural gas puts upward pressure on natural gas prices during winter which serves to compensate those who place gas in storage during lower-price, off-peak periods. Regulated local distribution companies, however, will place gas in storage for peak demand independent of prices because they are responsible for providing reliable natural gas service to their customers. Thus, natural gas inventory levels are driven, in part, by the reliability obligation of local distribution companies in addition to market factors.

Despite the storage of natural gas and the industry's recognition that demand will rise in the winter months, winter natural gas prices can fluctuate quite dramatically with changes in weather and the amount of natural gas in storage. The reasons for this price volatility are straight- forward. For example, if storage levels appear to be low in autumn, there will be concern that it will be difficult to meet peak demands throughout the winter, and traders may be willing to pay more to secure natural gas volumes for winter month deliveries. This results in upward pressure on market prices. In contrast, warmer than expected weather can lead to high levels of storage inventory throughout the winter, and natural gas prices may decline in response to the ample supplies.

The low natural gas prices are leading many analysts to believe that there will be substantial natural gas demand growth in the future, especially in the electric and industrial sectors (see **Figure 15**). On the electric side, the combination of low natural gas prices and emerging environmental regulations is leading to the retirement of a significant amount of coal-fired generation capacity. Many retirements have been announced and additional retirements are expected. Natural gas-fired generation is expected to replace a significant portion of the lost coal-fired generation, thus leading to expectations of increasing natural gas demand in the electric sector. The natural gas demand growth could be particularly strong in the Midwest and Southeast U.S., given the large amount of coal-fired generation capacity and the potential for significant retirements in those regions. Of course, intermittent renewable energy sources may also replace some of the lost coal-fired generation when those renewable sources are available and operating, so the overall growth in electric sector natural gas demand resulting from coal plant retirements is uncertain and will ultimately depend on the future electricity generation mix. On the industrial side, the low natural gas prices are also causing a resurgence in industrial activity that may lead to increased natural gas demand. For example, *methanol* and fertilizer plants use substantial quantities of natural gas as a feedstock, and low natural gas prices have resulted in proposals to build many more of these facilities (particularly in the Gulf Coast).

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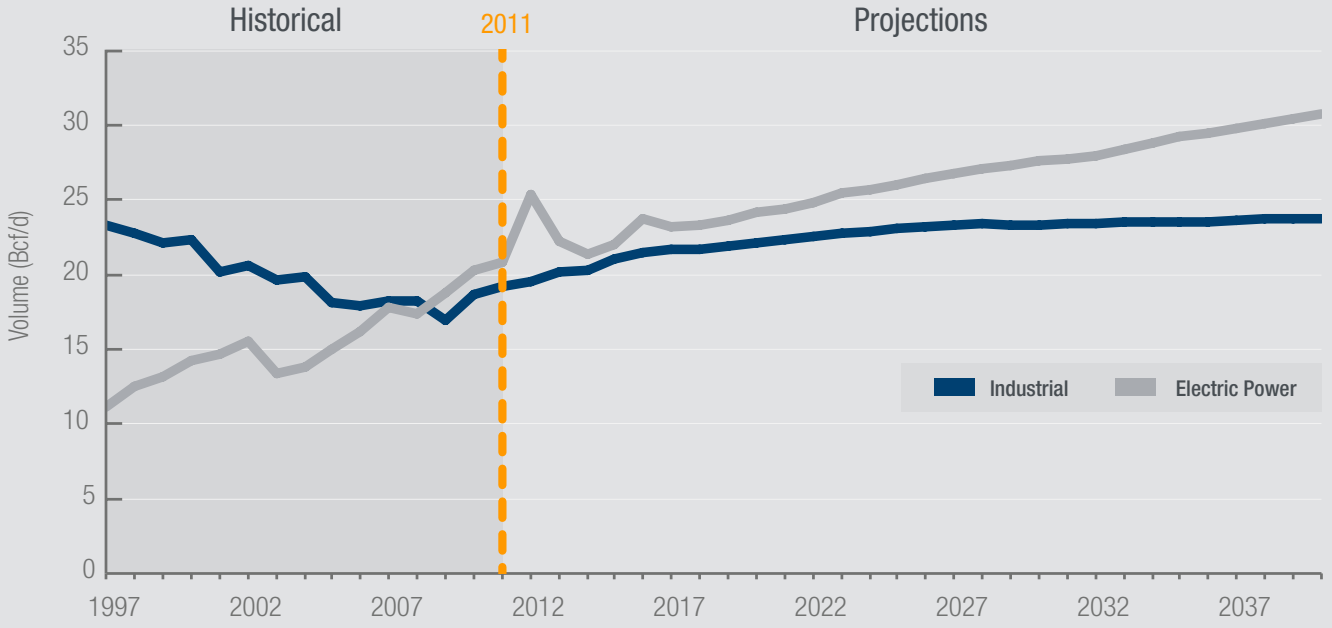
NATURAL GAS DEMAND FOR INDUSTRIAL AND ELECTRIC POWER SECTORS



Source: 1997–2011 data for industrial natural gas demand from EIA. 1997–2011 data for electric sector gas demand from EIA AEO 2013. 2012–2040 data from EIA AEO 2014 Early Release.

Natural Gas Exports

Low natural gas prices in North America are leading to proposals for the development of large LNG export projects.

These projects would liquefy natural gas supplies produced in North America so that they could be transported overseas by ship and sold to countries that do not have sufficient supplies from local production or via pipeline imports to meet their natural gas requirements. LNG is already imported by some Asian countries, such as Japan, South Korea, China, and India. The prices these countries pay for LNG has historically been linked to oil prices, and therefore LNG supplies have been relatively expensive. **Figure 16** shows the relationship between U.S. natural gas prices at Henry Hub and oil prices as measured by the Brent benchmark world oil price. Starting around 2009, U.S. natural gas prices began to disconnect substantially from oil prices as a result of the increase in shale gas production. This significant oil-gas price differential is ultimately what is driving many of the proposals for LNG export projects that have been announced in the past few years.

LNG export projects have been announced on the Gulf Coast, East Coast, and West Coast of the United States, as well as in Alaska and British Columbia. How many of these projects advance to the construction phase is uncertain due to uncertainty in how much LNG demand there will be from overseas countries, and competition from other sources of LNG to serve the demand (such as Australia, where several LNG terminals are already under construction). In addition, these projects require substantial capital investment (running into the tens of billions of dollars), and so project sponsors require long-term contracts before proceeding to construction to ensure they recover their investment and a reasonable rate of return. These projects also require approval from regulatory bodies, such as the Department of Energy and the Federal Energy Regulatory Commission in the United States, and the National Energy Board in Canada. In addition, some projects also face certain infrastructure challenges that may put them at a disadvantage, such as the British Columbia, Alaska, and U.S. West Coast projects that are at some distance from natural gas supplies and therefore require large pipelines to be constructed, in some cases over difficult terrain.

Aside from these LNG projects, it is expected that the U.S. also will export natural gas to Mexico and Canada. The U.S. already exports natural gas to Mexico, and pipeline expansion projects will result in an increasing amount of exports to Mexico in the coming years. The U.S. has historically been an importer of natural gas from Canada, especially into the western and Midwest U.S., but has also recently started to export some supplies to Ontario, Canada as a result of growing supplies in the Marcellus.

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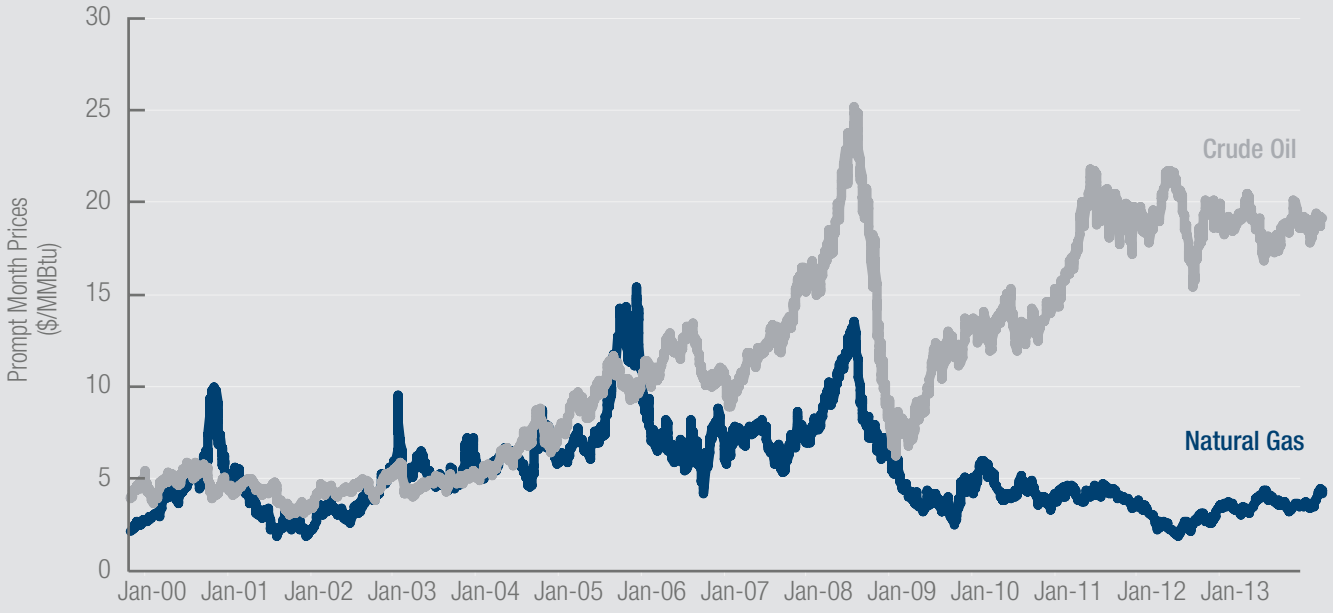
NYMEX PROMPT MONTH PRICES, CRUDE OIL VS. NATURAL GAS, JANUARY 1994–DECEMBER 2013



Source: NYMEX data downloaded from EIA and Bloomberg. The crude oil prices are for Brent Crude, 1-Month Forward Contracts.

How Natural Gas is Traded

Figure 17 shows schematically some of the types of natural gas transactions that take place as gas makes its way from the fields where it is produced to end users' burner tips. The natural gas industry in the United States is highly competitive, with literally thousands of producers.[11] Some producers have the ability to market their natural gas and may sell it directly to local distribution companies or to large industrial buyers of natural gas. (Some of these large industrial buyers are "on-system" end users, meaning that they receive physical natural gas deliveries from a local distribution company. Others are "off-system" end users, meaning they are directly connected to an interstate pipeline.) Other producers sell their gas to marketers who have the ability to aggregate natural gas into quantities that fit the needs of different types of buyers and to transport gas to their buyers. Marketers may be large or small and sell to local distribution companies or to commercial or industrial customers connected directly to pipelines or served by local distribution companies.

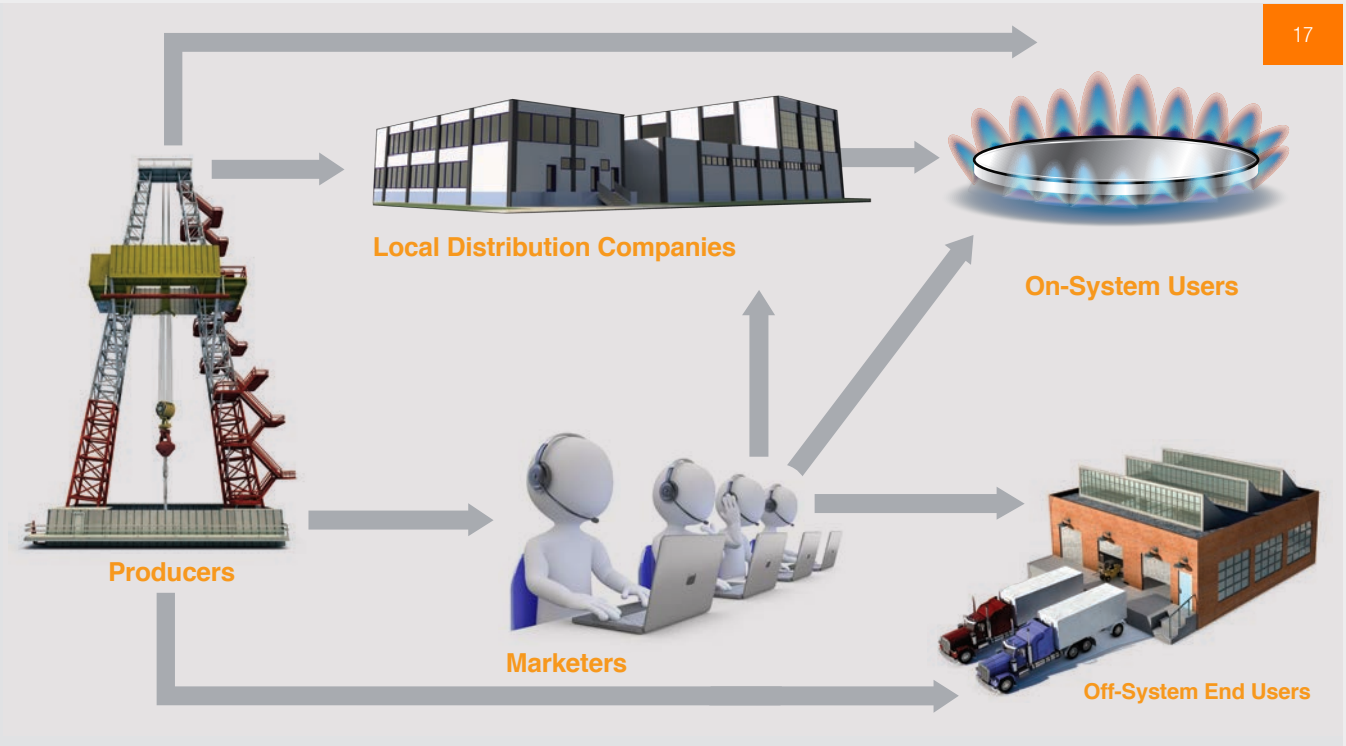
Most residential and commercial customers purchase natural gas from a local distribution company. In contrast, many industrial customers have the option to purchase natural gas from a marketer or producer instead of from the distribution company.

There are many different types of buyers and sellers who are motivated to buy and sell gas under different types of commercial arrangements. As a result, gas is sold on a *spot market* basis, under longer-term contracts with fixed pricing or terms that track market prices, and under contracts with other types of pricing provisions. Marketers are able to meet customers' differing needs by bringing together a large number of buyers and sellers. In addition, marketers and other buyers and sellers of natural gas are able to use financial instruments traded on exchanges to hedge the risks associated with price volatility.

Note that pipeline companies do not buy and sell natural gas. Most of the major natural gas pipelines are federally regulated interstate pipelines. These pipelines are limited to providing transportation services, including storage.[12] Thus, pipelines move gas at government-regulated rates on behalf of buyers and sellers, but do not participate in the buying and selling of natural gas.

The domestic natural gas marketplace has a highly active spot market where *brokers* and others buy and sell natural gas. **Figure 18** shows some of the points where natural gas for physical delivery is actively traded in the continental United States and Canada. Many of these locations are segments of individual pipelines or locations where pipelines interconnect with other pipelines or local distribution companies. Brokers trade natural gas at these locations and prices

COMMERCIAL AND FINANCIAL ARRANGMENTS



are established, although there are varying degrees of trading activity at these different locations.

The benchmark price for North American natural gas is the Henry Hub, located in southern Louisiana. The Henry Hub is interconnected with 13 different intra- and interstate pipelines. Because of its central location and its high degree of interconnectedness, the Henry Hub is used as the delivery point for the New York Mercantile Exchange's (NYMEX) natural gas *futures contract*. While Henry Hub has served as the pricing reference point for virtually the entire North American natural gas market, other locations have also become important market trading points, such as Alberta, Canada, Chicago Citygate, and Dawn, Ontario, with some of these locations having an even larger number of spot market transactions than Henry Hub.

Market participants buy and sell natural gas on a "spot" basis every day at the trading points shown in **Figure 18**, as well as at dozens of other points. Spot market transactions are normally conducted over the internet or by telephone, with the buyer agreeing to pay a negotiated price for the natural gas to be delivered by the seller at a specified delivery point. Natural gas spot prices reflect daily supply and demand balances and can be volatile.

In addition to daily spot transactions, monthly spot transactions are often entered during "bid week," the last five business days of a month. During bid week, buyers and sellers arrange for the purchase and sale of physical natural gas to be delivered throughout the coming month, including making delivery arrangements with pipelines.

Many customers purchase natural gas under longer-term contracts that provide for delivery of gas for a specified period of time. The length of time can vary. Frequently the prices in longer-term contracts are not fixed, but are instead indexed to prices that are regularly published in the trade press. A number of trade publications publish index prices based on their surveys of natural gas buyers and sellers to determine the prices they pay (or receive) for natural gas (at market locations such as those shown in **Figure 18**) in daily or monthly transactions.

THE TOP 25 NORTH AMERICAN GAS TRADING LOCATIONS

18

NOTE: Transaction volume data from Platts Gas Daily used to identify the top 25 trading locations.

Futures and Other Financial Contracts

In addition to the contracts for physical supply described previously, natural gas derivatives are traded on the New York Mercantile Exchange. A NYMEX natural gas futures contract requires the seller to deliver (and the buyer to take delivery of) natural gas at the contractually agreed price, in a specified future month, at the Henry Hub.[13] The price to be paid for delivery in the future month when the futures contract matures is determined at the time the contract is sold. As expectations about the value of natural gas at the time of delivery change, the value of the futures contract will change as well.[14]

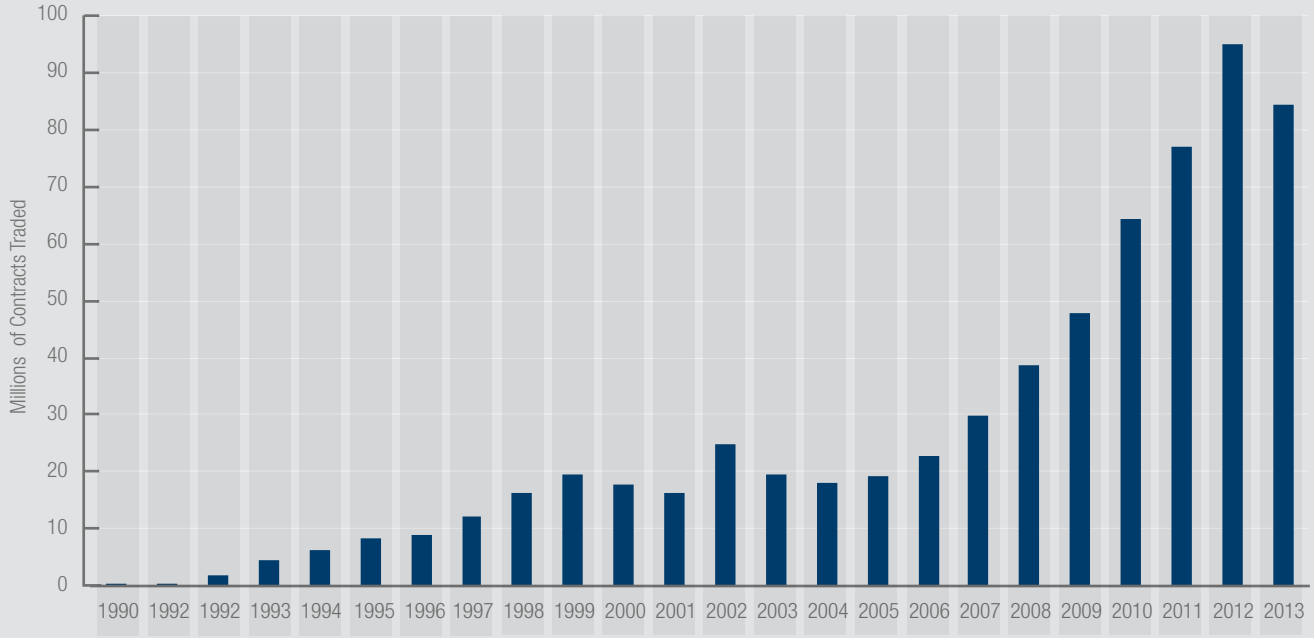
Derivatives such as the NYMEX futures contract make it possible for market participants to reduce the risk that results from highly volatile natural gas prices in the physical market. For example, a manufacturing facility that uses natural gas may face highly volatile cash flows as a result of dramatic fluctuations in natural gas prices from month to month and day to day. To reduce these risks, the facility can purchase physical natural gas using contracts that reference or are indexed to spot market prices and, in addition, purchase financial derivatives that rise in value when gas prices rise and fall in value when gas prices fall. The result is that when prices are high, the value of the derivatives will rise to offset the additional cost of gas, and vice versa.

The futures market for natural gas has grown rapidly from its inception in 1990. **Figure 19** shows the number of natural gas contracts traded on the NYMEX each year between 1990 and 2013. This market is made up of a large number of buyers and sellers, as well as different types of buyers and sellers. Parties with commercial interests frequently use futures contracts to reduce their exposure to price risk by locking in the price they will pay (or receive) for natural gas to be delivered in some future month. For example, a natural gas producer who expects to produce and sell natural gas each month for the next several years can use the NYMEX futures contract to lock in the price that the producer will receive for that gas. Likewise, a local distribution company buyer of natural gas may buy NYMEX futures contracts to reduce price risk on behalf of its residential and commercial customers.

In addition, the market includes parties who are not commercial entities seeking to hedge their exposure to price risk. These non-commercial traders may include investment banks, hedge funds and other commodity investors who hold natural gas futures contracts as part of a diversified investment portfolio, or who buy and sell futures contracts in response to contract prices, seeking to make a return for bearing risk. While the role of non-commercial traders in futures markets has been a controversial subject at times, it is clear that these non-commercial participants play an important role in helping commodity markets function efficiently. They serve as counterparties to commercial hedgers in futures markets, providing liquidity that assures the commercial parties will not incur excessive

19

NATURAL GAS FUTURES CONTRACTS TRADED BY YEAR, 1990–2013



Source: Bloomberg. Annual volumes for 1990 begin in April.

costs to effectively manage their risks. The market benefits from the activity of all types of traders because—by bringing different perspectives—they help ensure that market prices reflect all of the information available about current and future supply and demand conditions.

Futures markets also provide valuable information about expectations for supply and demand conditions in the physical market that will determine the price for gas scheduled for delivery on a specified future date. For example, if in 2014 the price of a futures contract for the delivery of gas in April 2015 is $4 per MMBtu, this represents thousands of buyers' and sellers' expectations of what the price of gas will be for physical delivery in April 2015.[15] This price discovery function is beneficial because it provides market information to those who can best respond by, for example, putting additional gas in storage or taking steps to switch to a different fuel.

Figure 20 shows some of the recent movement in natural gas futures prices at different points in time over the past few years. Each line in the figure shows prices for natural gas to be delivered in each of the next 36 months. As shown, there has been substantial volatility in natural gas futures prices in the recent past as the market's perception of natural gas market conditions changed over time. In June 2008, before shale supplies started coming on line in substantial quantities, the market was expecting relatively high prices with significant peaks during the winter period versus the summer period. More recently, as larger quantities of shale production have come on line, market participants expected lower prices to prevail that have less of a winter peak than was the case historically.

In addition to exchange-traded natural gas futures contracts, natural gas derivative contracts are also traded in *over-the-counter* (OTC) markets. The *bilateral trading* that occurs in OTC markets includes forward contracts and *swaps*, which are generally non-standardized contracts that can be tailored to the specific needs of the counterparties involved in the transaction. The OTC markets where such transactions occur were previously largely unregulated.

In response to the 2008 financial crisis, the Dodd-Frank Wall Street Reform and Consumer Protection Act ("Dodd-Frank") was enacted into law on July 21, 2010, making sweeping changes to the regulation of U.S. financial markets. Dodd-Frank was aimed at reducing risk in the financial system, improving the transparency and efficiency of financial markets, and increasing regulatory oversight. Dodd-Frank is heavily focused on financial institutions and systems, but also affects non-financial institutions including participants in the natural gas industry that trade natural gas derivative contracts. While some of the specific regulatory rules are still under development, Dodd-Frank will affect the natural gas industry with rules regarding swaps trading and associated clearing and margin requirements, position limits, and reporting requirements.

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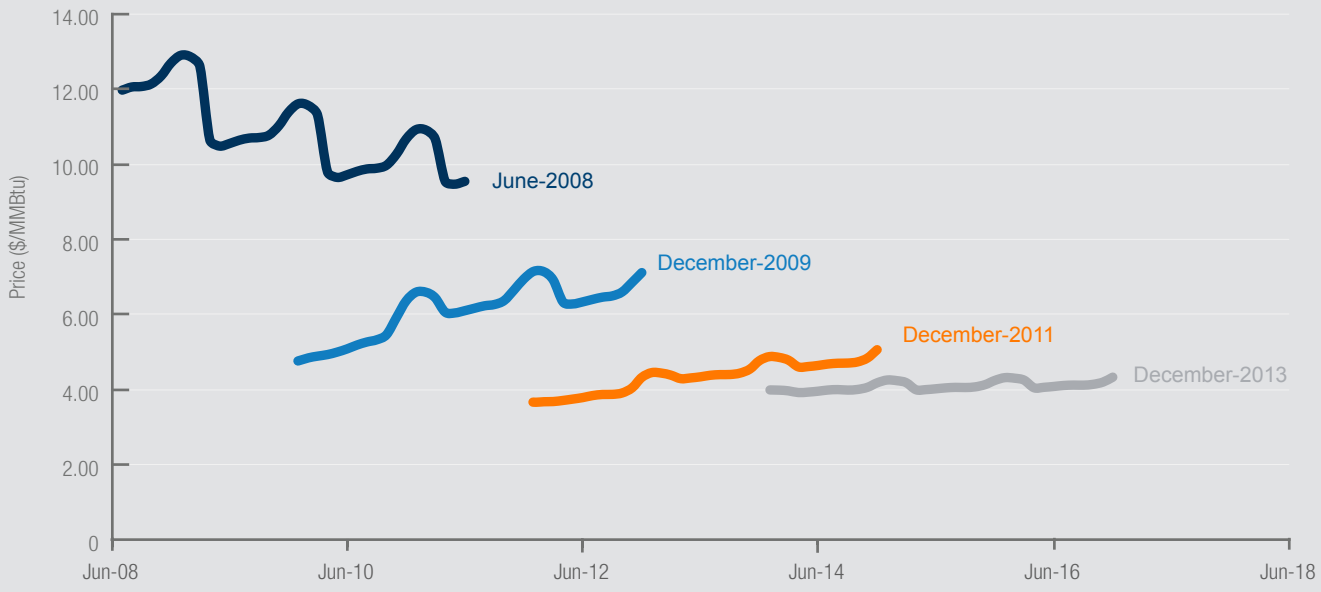
NYMEX HENRY HUB MONTHLY FUTURES PRICES (June 2008–December 2013)



Source: Bloomberg. Forward curves are based on the first trading day of the given month.

Conclusion: A New Era For U.S. Natural Gas Markets

The U.S. natural gas industry has changed dramatically

as a result of technological advancements that have resulted in increasing domestic production, especially from shale resources. These new supplies of natural gas have resulted in lower prices and reduced price volatility, and expectations of increasing demand. Natural gas use for electricity generation is expected to grow, in part due to the expected retirement of some coal-fired generation capacity. Industrial consumption of natural gas is also expected to increase due to a resurgence of petrochemical plants, especially in the U.S. Gulf Coast. Low domestic prices relative to the prices available in world markets are also leading to proposals to export natural gas as LNG. The emergence of shale gas in abundance has profoundly changed the market for natural gas in the U.S. in recent years, and perhaps for the foreseeable future.

Glossary

Associated Natural Gas

Natural gas that occurs in crude oil reservoirs either as free gas (associated) or as gas in solution with crude oil (dissolved gas). Natural that is not in contact with significant quantities of crude oil in the reservoir is referred to as non-associated natural gas.

Processing Plant

Bilateral Trading

Bilateral or OTC transactions between two parties are not cleared in exchanges. These transactions can occur through direct contact and negotiation, through a voice broker or through an electronic brokerage platform, such as the Intercontinental Exchange (ICE). The deals can range from standardized contract packages, such as those traded on ICE, to customized, complex contracts known as structured transactions.

British Thermal Unit (Btu)

A British Thermal Unit (Btu) is the amount of energy required to raise the temperature of one pound of water by one degree Fahrenheit. This is the most common unit used for buying and selling natural gas. Average annual natural gas usage per customer in the U.S. is roughly 60 MMBtu.

Broker

A broker is an intermediary that arranges transactions between a buyer and a seller for a commission when the deal is executed.

Coalbed Methane

Coalbed methane is natural gas contained in coal deposits. Typical recovery entails pumping water out of the coal to allow the gas to escape.

Cubic Foot (cf)

A cubic foot (cf) is a standard measure of natural gas, equal to the amount of natural gas contained at standard temperature and pressure (60 degrees Fahrenheit and 14.73 pounds standard per square inch) in a cube whose edges are one foot long. There are 1,031 Btu in a cubic foot of natural gas. MMCF (million cubic feet), BCF (billion cubic feet) and TCF (trillion cubic feet) are common abbreviations used in the natural gas industry.

Deep Gas

Deep gas is natural gas found at depths greater than the average for a particular area; for FERC purposes, it is gas found at depths of more than 15,000 feet.

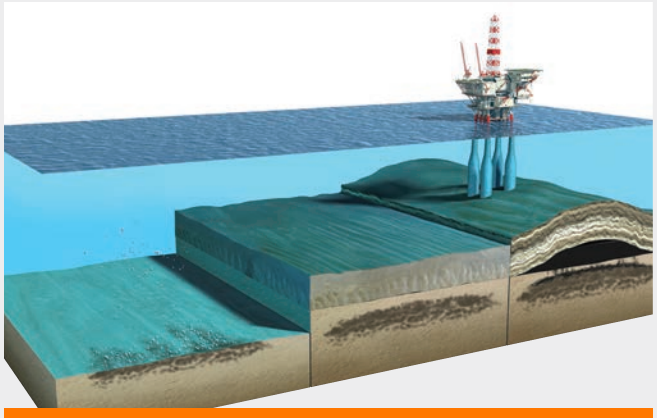
Drilling Rig

A machine which creates holes in the ground, used to drill oil and gas wells. Usually, the drilling rig is moved off of the well once the well has been drilled so that it can be used to drill another well.

Driling Rig

Deepwater

Deepwater natural gas is natural gas located in the Gulf of Mexico in waters at least 200 meters (656 feet) deep.



Deepwater Driling

Dry Gas

Dry gas is natural gas which remains after: 1) the liquefiable hydrocarbon portion has been removed from the gas stream (i.e., gas after lease, field, and/or plant separation); and 2) any volumes of non-hydrocarbon gases have been removed where they occur in sufficient quantity to render the gas unmarketable. Note: Dry natural gas is also known as consumer-grade natural gas. The parameters for measurement are cubic feet at 60 degrees Fahrenheit and 14.73 pounds per square inch absolute.

Dry Wells

Dry wells are exploratory or development wells found to be incapable of producing either oil or gas in sufficient quantities to justify completion as an oil or gas well.

Futures Contract

A futures contract is a binding, legal agreement between a buyer and a seller for delivery of a particular quantity of a commodity at a specified time, place, and price. These contracts are traded on regulated exchanges and are settled daily based on their current value in the marketplace. Most natural gas futures contracts traded on the New York Mercantile Exchange (NYMEX) end without actual physical delivery of the commodity. Futures contracts most often are liquidated or cancelled out by purchasing a covering position prior to the delivery date and are generally used as a financial risk management and investment tool rather than for supply purposes.

Horizontal Drilling

Horizontal drilling is a drilling methodology where wells are turned horizontally at certain depth. It is normally used to extract energy from a source that runs horizontally, such as a layer of shale rock.

Drilling Rig Machinery

Hydraulic Fracturing

Hydraulic Fracturing is the propagation of fractures in a rock layer, as a result of the action utilizing a pressurized fluid, chemical additives, physical proppants, or a combination thereof, to release petroleum, natural gas, or other substances to be extracted. Hydraulic fracturing along with horizontal drilling is utilized to produce hydrocarbons from shales.

Liquefied Natural Gas (LNG)

Liquefied natural gas (LNG) is natural gas that has been liquefied by reducing its temperature to -260 degrees Fahrenheit at atmospheric pressure. This liquefaction process reduces the volume of the gas by approximately 600 times from its original size.

Methanol

Methanol is used in a wide range of products, including paints and glue. Methanol plants use natural gas as a feedstock.

Natural Gas Liquids

Natural gas extracted out of a well may be comingled with other hydrocarbons. These hydrocarbons that are in liquid form are separated from natural gas and are referred to as natural gas liquids. NGLs are used as inputs for petrochemical plants, burned for space heat and cooking, and blended into vehicle fuel.

Over-the-Counter (OTC)

Over-the-counter (OTC) transactions are transactions that are not cleared on an organized exchange.

Shale Gas

Shale gas is natural gas that is trapped within fine-grained sedimentary rock formations. Shale gas has recently become a major source of domestic natural gas production.

Spot Market

The natural gas spot market is a market in which natural gas is bought and sold for immediate or very near-term delivery, usually for a period of 30 days or less. The transaction does not imply a continuing arrangement between the buyer and the seller. A spot market is more likely to develop at a location with numerous pipeline interconnections, thus allowing for a large number of buyers and sellers. The Henry Hub in southern Louisiana is the best-known spot market for natural gas.

Swaps

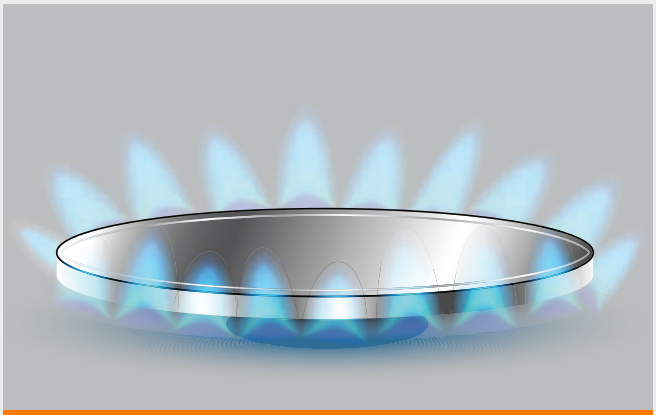
Swaps are financial or physical transactions in which two parties agree to exchange different cash flow streams or physical gas products. For example, in a fixed price swap, the swap buyer agrees to pay the swap seller a fixed price (e.g., $4.00/MMBtu) and the swap seller agrees to pay the buyer an index price (e.g., the Southern California index price). In a basis swap, the swap buyer agrees to pay the seller the NYMEX Henry Hub price plus or minus a fixed amount (e.g., +$0.25/MMBtu) and the swap seller agrees to pay the buyer an index price (e.g., the PG&E Citygate index price). In a physical swap transaction, gas at one location is traded for gas at another location.

Technically Recoverable

Technically recoverable resources are those that are producible using current technology without reference to the economic viability thereof.

Unconventional Gas

Unconventional gas refers to natural gas extracted from coalbeds (coalbed methane) and from low-permeability sandstone and shale formations (respectively, tight sands and gas shales). Unconventional gas has become an increasingly important component of total U.S. domestic production over the past decade.



Natural Gas

References

1. Italicized words appear in the glossary.
2. See "Annual Energy Outlook-2014 Early Release Overview," p. 13. EIA notes that, in its reference case, the U.S. is predicted to become a net exporter of LNG in 2016 and an overall net exporter of natural gas in 2018.
3. Energy Information Administration, http://www.eia.gov/totalenergy/data/annual/index.cfm#summary
4. See API primer "Offshore Access to Oil and Natural Gas Resources," July 2014.
5. See Energy Information Administration, Energy in Brief, "What is shale gas and why is it important?," http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm
6. EIA, "Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States," June 2013. Also see EIA presentation "Annual Energy Outlook 2012 Early Release Reference Case," January 23, 2012, slide 10.
7. "EIA Drilling Productivity Report," presentation by EIA Administrator to Columbia University Center on Global Energy Policy, October 29, 2013.
8. See "EIA to release new Drilling Productivity Report," October 21, 2013 at http://www.eia.gov/todayinenergy/detail.cfm?id=13451.
9. See Facts about Natural Gas 2013, American Gas Association (AGA) at http://www.aga.org/Newsroom/factsheets/Documents/Facts%20About%20Natural%20Gas%202013.pdf
10. According to the U.S. Census Bureau's 2011 American Housing Survey, natural gas is used as the main heating fuel in 57 million homes out of total of 114 million housing units using heating fuel, or roughly 50% of households.
11. As noted previously, federal and state agencies regulate the prices charged by most natural gas pipelines and local distribution companies for the transmission and distribution services they provide. The price of the natural gas commodity itself has not been regulated since 1993.
12. Prior to the federal restructuring of regulation of the interstate natural gas pipeline system, natural gas pipelines purchased gas from producers and sold it to the customers connected to the pipeline. This system was inefficient because it severely limited the number of buyers for natural gas and kept the market from operating competitively. These regulations were part of the overall regulation of the natural gas industry that was dramatically altered beginning in the late 1970s through the mid-1980s.
13. The NYMEX natural gas futures contract stipulates the purchase and sale of 10,000 MMBtu of natural gas at the Henry Hub trading point in Louisiana in the delivery month.
14. Other NYMEX-traded natural gas derivatives include options contracts, calendar spread options, and basis swap futures contracts. In addition to the derivatives available on NYMEX, market participants trade other derivatives in over-the-counter (OTC) markets.
15. The academic literature discusses whether there are risk premiums in futures prices that affect the relationship between futures prices and expected future spot prices, a subject that is beyond the scope of our discussion here.

This report was prepared for the American Petroleum Institute. All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group, Inc. or its clients.

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