SPECIAL REPORT

TD Economics

November 15, 2012

THE SHALE SHIFT

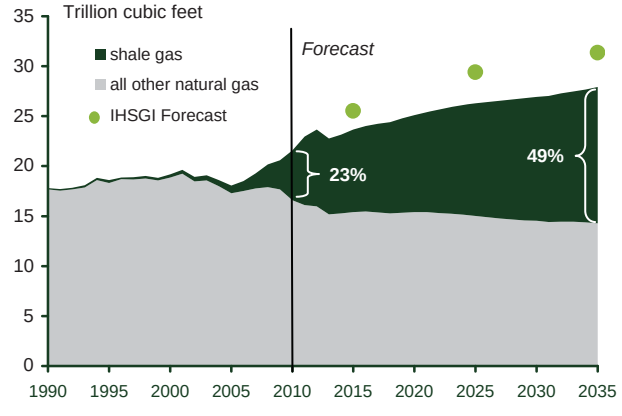
Exploring the impact of shale gas on the U.S. economy

Highlights

- The advent of shale gas production in the U.S. has already changed the game for the North American natural gas market. It has reversed the stagnating trend in U.S. natural gas production, reduced the need for imports and lowered the U.S. price of natural gas relative to other fuels and prices elsewhere in the world.
- Lower prices have cut costs for businesses and consumers, and dramatically shifted the economics of power generation. Going forward, the likelihood of continued favorable prices relative to alternative fuels will shape the U.S. power mix; improve the economics in certain industries and for natural gas as a transportation fuel. Increased use of natural gas will also continue to help reduce greenhouse gas emissions as it displaces coal in the power sector.
- However, the outlook for supply and demand, and hence prices, is highly sensitive to two main uncertainties: the actual recovery rates of shale gas plays going forward, and the regulatory environment.

The advent of shale gas production in the U.S. has already changed the game for the North American natural gas market. Technical advances in natural gas extraction over the past decade resulted in the doubling of the estimated supply of recoverable natural gas in the U.S. from 2009 to 2011. The production of natural gas from shale using a combination of hydraulic fracturing and horizontal drilling has rejuvenated the natural gas industry in the United States, reversing stagnating production trends (see Chart 1) and dramatically reducing the need for imports. The most meaningful result of this sea change has been far lower natural gas prices than would otherwise have been the case. Were it not for increased production of shale gas, the price of natural gas would likely be in the neighborhood of $10-12/MMBtu[1], versus the approximately $3.50/MMBtu level it is today.

CHART 1. SHALE GAS TO DRIVE U.S. PRODUCTION GROWTH

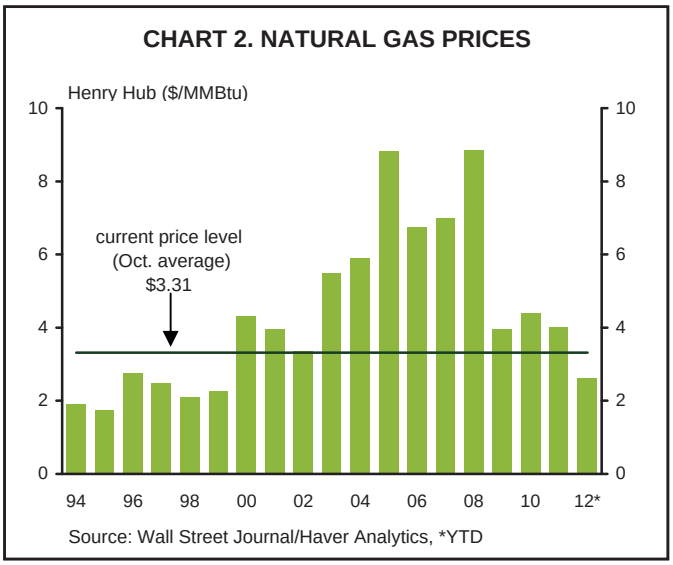


Source: EIA AEO 2012

The fall in prices has been remarkable. Over the past four years, the price of natural gas has been over 50% lower than it was in the previous four years (see Chart 2). Part of the decline in price has been due to such strong production growth within a relatively mature North American market, but it is also due to the nature of shale gas production. While shale gas wells are expensive to drill relative to conventional gas wells, the full-cycle cost of shale gas wells in 2011 is 40-50% less than conventional wells[2]. The initial capital outlays are higher, but the production from one well is also far higher.

Not only are natural gas prices lower in absolute terms, they have shifted relative to both alternative fuels, and prices in Europe or Asia. The North American price of natural gas at the Henry Hub

Leslie Preston, Economist, 416-983-7053
James Marple, Senior Economist, 416-982-2557



in Louisiana, currently around $3.50/MMBtu, compares favorably with oil-linked prices of roughly $12 per MMBtu in Europe and $16 per MMBtu in Asia. The price of natural gas in North America has also decoupled from its traditional relationship with the price of oil, and has improved its position relative to coal (see Chart 3). The change in relative prices has shifted the economics in favor of greater gas use.

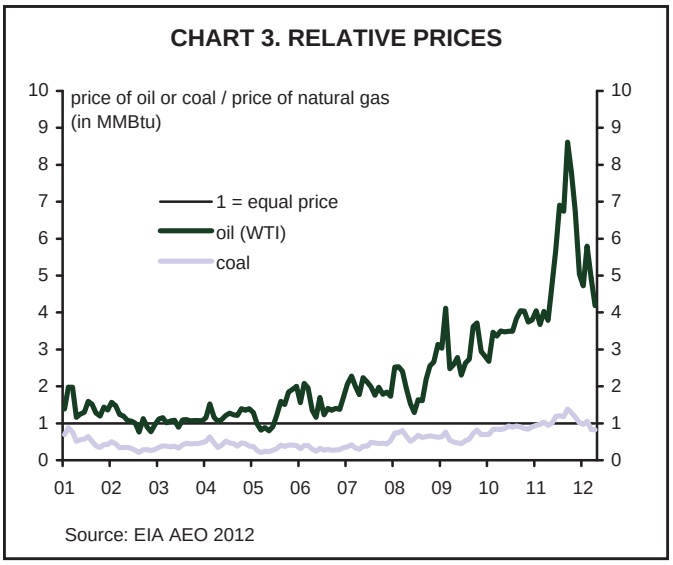
The growth in domestic natural gas production and resulting lower prices presents many opportunities for the U.S. economy. There are economic benefits in certain regions from growing activity within the natural gas supply industry itself (see Text Box, next page), but perhaps more important for the broader U.S. economy is the impact on how much natural gas is consumed, and how much Americans pay for it. Lower relative natural gas prices are affecting the power generation sector, industrial applications and residential and consumer use. Favorable pricing has also raised the prospects for greater use as a transport fuel. And, if forecasts play out as expected, the U.S. will also be in a position to meet foreign demand for natural gas through exports of liquefied natural gas (LNG) overseas.

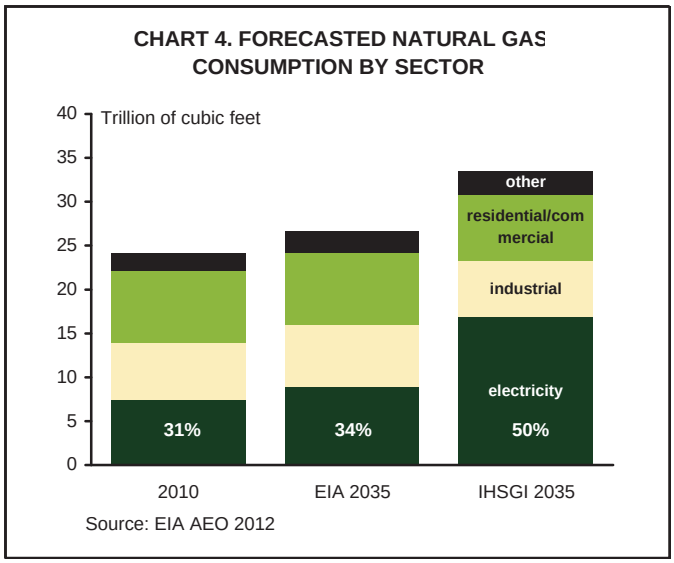
Finally, however, there are a few uncertainties that loom large over the outlook. Since shale gas production is expected to be a large proportion of North American natural gas production, changes in the costs and productivity of shale wells have a significant effect on projected natural gas prices. The range between the Energy Information Agency's (EIA) high and low well productivity scenario is $8-4/MMBtu (in 2010$ terms) in 2035, demonstrating the impact shale gas resource uncertainty has in determining future natural gas prices. This has notable effects on the economics of natural gas use across sectors of the economy. Apart from resource economics, there is also uncertainty surrounding the future regulatory environment for both the extraction and use of natural gas that will further shape the outlook.

Shale gas has changed the game for power generation

The greatest scope for increased natural gas demand in the United States is in power generation. Public and private sector forecast scenarios both see demand from the electricity sector driving the largest increase in natural gas demand out to 2035 (see Chart 4).

Traditionally coal has been the dominant fuel for power generation, accounting for roughly half of all generation early in the last decade. However, 82% of new capacity additions over the past 10-12 years have been natural gas-fired (see Chart 5). This has resulted in natural gas making up an



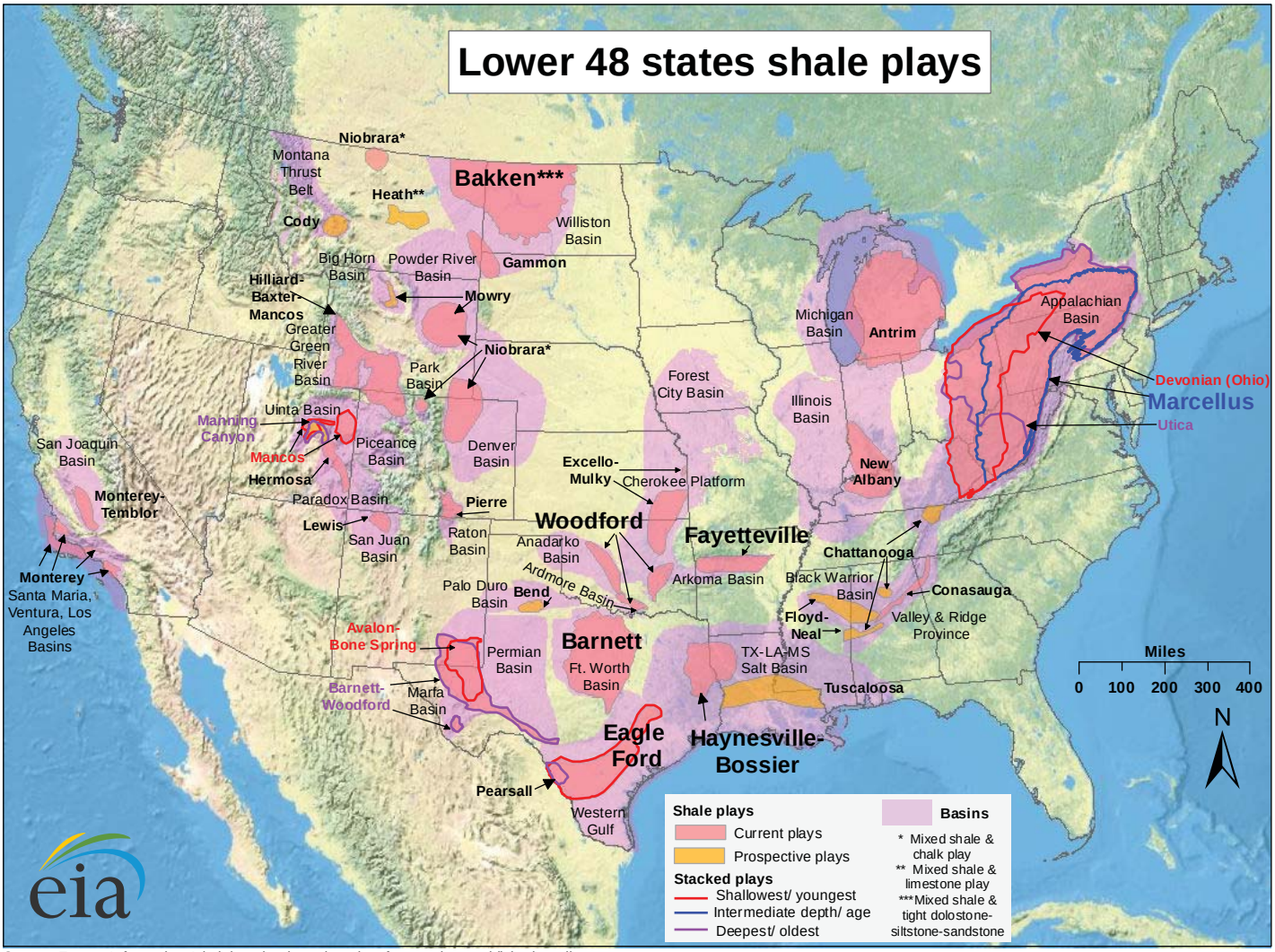


Where are the shale plays and what are the direct benefits?

Shale gas refers to natural gas that is trapped within shale formations. Over the past decade, the combination of horizontal drilling and hydraulic fracturing has allowed access to large volumes of shale gas that were previously uneconomical to produce. Shale gas is found in shale "plays," which are shale formations containing significant accumulations of natural gas and which share similar geologic and geographic properties. Six major shale gas plays in the U.S. – Haynesville, Eagle Ford, Marcellus, Fayetteville, Woodford and Barnett (see map below) – represent 40% of the total estimated natural gas resource base.

Drilling programs in Pennsylvania's shale formations, like those in other, more established plays such as the Barnett and Eagle Ford in Texas, are migrating to more liquids-rich areas due to the price premium of crude oil and natural gas liquids.

A recent study from IHS Global Insight estimated some of the direct and indirect benefits from shale gas production over the period from 2010 to 2035, and we will summarize some of the results here. Shale gas production has generated 148, 000 direct jobs in 2010, and is expected to rise to roughly 200, 000 by 2015 , not a huge number in the broader scope of the U.S. labor market, but a notable impact in the local areas. The resource is also a boon to governments through tax revenues and royalties, as well as individual landowners who lease their land to drillers. Government revenues are expected to be $933 billion from 2010-2035, amounting to roughly $37 billion per year, (about 1% of government's share of GDP). The contribution would be slightly more per year in capital spending $76 billion per year on average to 2035, or an additional 4.6% on average per year to business investment spending.



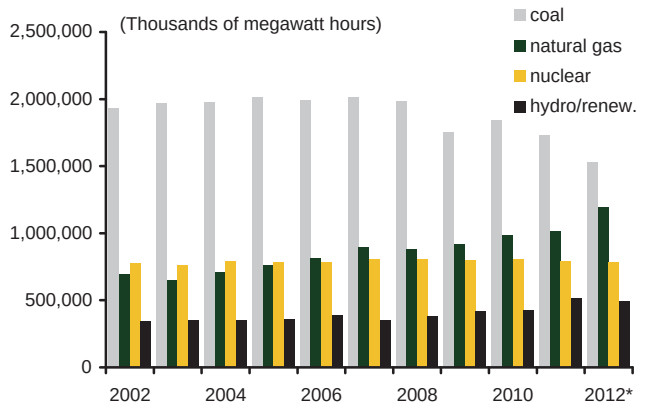
Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

increasing share of actual power generation, at the expense of coal-fired generation (see Chart 6). In fact, natural gas passed nuclear power as the number two source of power in 2006, and in April of this year natural gas and coal had the same share of total net generation of electricity at 32%, for the first time.

The current price dynamics between coal and natural gas have favored gas-fired generation over coal over the past year. While the price of natural gas and coal currently seem to be neck and neck on an energy equivalent basis (refer back to Chart 3), this does not account for the differences in energy conversion efficiency among different types of generators. Gas-fired combined cycle units tend to be more efficient than coal-fired steam units. On an equivalent energy content and efficiency basis, the average June 2012 price in $/MWh for Central Appalachian coal was higher than the price of natural gas at Henry Hub for the eleventh straight month.

Environmental regulations, renewable energy mandates, and economics all support increased use of gas in power generation. Natural gas generation is cleaner burning (less sulfur, mercury and particulate matter than coal), and using efficient combined cycle turbines generates only half the GHG emissions as coal. Gas-fired generation plants are also cheaper and faster to build than other types of generation, making them attractive "no regret" investments to utility operators. They are also cheaper to add carbon capture and sequestration equipment to down the road if carbon pricing were to be implemented. Finally, the ease of powering up and down gas-fired generation makes it an ideal partner for more intermittent renewable sources of power like solar or wind. So increased renewable power mandates also helps favor gas-fired capacity additions going forward.

CHART 6. POWER GENERATION BY ENERGY SOURCE

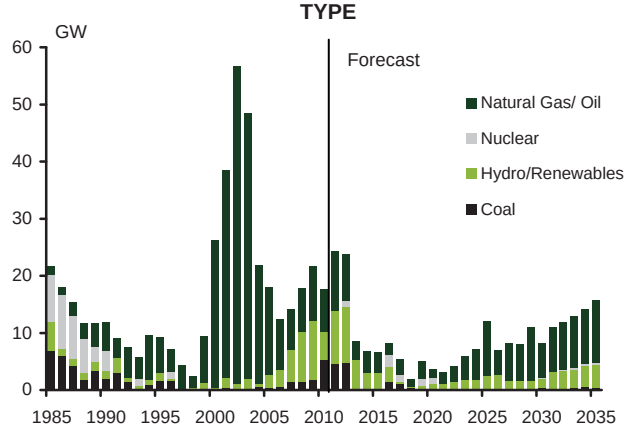


Source: EIA, *12 months to August

As natural gas displaces coal, GHG emissions will be reduced and consumers will see lower electricity prices. The increased use of relatively lower priced natural gas for power generation has already helped to lower electricity costs in the U.S. Since 2009, real electricity prices have fallen 7.6% (see Chart 7). IHS Global Insight (IHSGI) estimates that lower natural gas prices due to shale production will result in an average 10% reduction in electricity costs over the next few years. Moreover, the displacement of coal-fired power generation with natural gas has helped drive greenhouse gas emissions in the U.S. to a 20-year low.

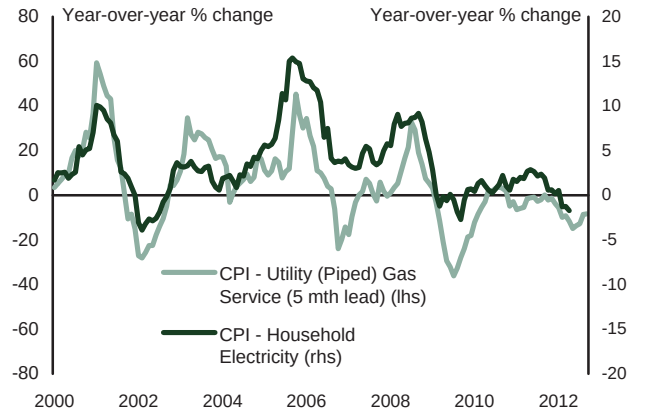
If at some point in the future, a price were to be put on carbon emissions, the use of natural gas in the power sector would increase even further. Moving from the EIA base case, which assumes current policies remain in place, to one

CHART 5. POWER CAPACITY ADDITIONS BY FUEL TYPE



Source: EIA AEO 2012

CHART 7. UTILITY GAS SERVICE PRICES & HOUSEHOLD ELECTRICITY PRICES



Source: Bureau of Labor Statistics, WSJ / Haver Analytics

where there is a $15 per metric ton price on carbon results in a 13% increase in the use of natural gas in power generation. Until renewable sources of energy become more cost effective, high efficiency natural gas is the most practical way to restrain carbon growth[3].

Residential and commercial segments see cost savings, but limited scope for demand growth

Residentially, natural gas is used directly for space heating and as fuel for stoves, water heaters and other appliances. In the United States, slightly more than half of homes are heated with natural gas. The next largest heating source is electricity at roughly 35%. Residential and commercial consumption account for 32% of all natural gas consumed.

Lower natural gas prices as a result of the shale gas revolution have benefited consumers directly by reducing the cost of home heating and electricity. We estimate that the reduction in natural gas price has saved American consumers an average of $45 billion over the last three years. Assuming natural gas prices average $3.75 over the next year; households will save around $75 billion in 2013, equivalent to about 0.6% of disposable personal income or $650 per household.

Despite lower prices, there is not a great deal of growth expected in natural gas demand from the residential and commercial markets, as energy demand for these sectors as a whole is expected to grow only slowly as efficiency improves. While there is some potential for further conversions from oil heat to natural gas in the Northeast, greater population growth in warmer regions – where electric heat dominates – will lean against residential demand growth.

Industrial consumption: game changer for a select few

As explored in a recent TD Economics report *"Offshoring, Onshoring and the Rebirth of American Manufacturing"* cheaper natural gas will have an impact across all the industries lowering production costs directly, with 28% of total manufacturing sector energy derived from natural gas and indirectly through electricity generation and lower refining costs. Across the entire manufacturing sector it should shave off around $50 billion in energy input costs on an annual basis. This amounts to less than 2% of intermediate input costs for the total U.S. manufacturing industry, which may not seem like much for the sector as a whole, but the benefits are likely to be concentrated among several heavy users. These include chemicals (which use it as an energy source but also as a feedstock), petroleum & coal, food & beverage, paper, and primary metals. These sectors consume nearly 80% of all natural gas used in the manufacturing sector, while the impact on the remaining industries is expected to be rather muted.

Already, production from the Marcellus formation has promoted rapid development of "cracking" plants which produce ethylene (some are in planning stages), used by the rubber & plastics industry as well as in agriculture. Examples include: Exxon Mobil, which plans to build factories that produce ethylene and plastics in Texas; Chevron Phillips Chemical Co. which plans on using more gas-based raw materials; Dow, which plans a new ethylene cracker in Texas; and Shell, which has another cracker planned in Pennsylvania. While these are large capital-intensive projects that will no doubt provide economic benefits to the local community, they are not huge job creators.

Natural gas in transportation – likely in niche markets

With the ratio of the price of oil relative to the price of natural gas very high by historical standards there is a lot of talk about the increased use of natural gas as a transportation fuel. This can either be achieved through compressed natural gas (CNG) or LNG vehicles. Much like switching from coal in the power sector, CNG emits significantly less pollutants compared to gasoline and fewer GHG emissions and is roughly half the cost of diesel as of this summer. Worldwide, CNG vehicles aren't new. Iran, Pakistan, Argentina, Brazil and India are all leading users of natural gas vehicles (Iran and Pakistan lack domestic oil refineries).

The U.S. has seen some industrial adoption of natural gas vehicles (NGVs) particularly for fleet vehicles that can run on a central fueling station. But, the high cost of switching and installing CNG fuelling stations are a big hurdle for wide scale adoption. California is a leader, with CNG vehicles used extensively in local city and county fleets and in public transportation (The City of Los Angeles, AT&T, UPS and Waste Management are just some who have made the switch).

As for wider use in consumer vehicles, NGVs have to compete against electric cars in the "alternative fuel" market. While the difference in upfront cost is a toss-up between the two, efficiency, availability of fuelling stations, and fuel costs all favor electric cars over NGVs. NGVs do have the advantage of a longer range and faster refueling time, which are more important for trucking and fleet applications. Overall, wide-scale adoption among consumer vehicles looks unlikely without preferential subsidies.

Currently, there is greater promise for natural gas in the

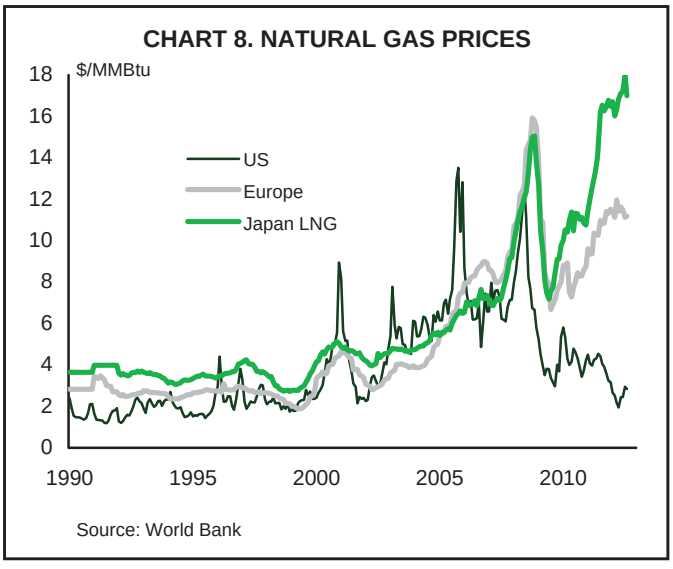
heavy-duty vehicle (HDV) market, mainly because under current technology it is difficult to run a truck on a battery. Industrial vehicles also look to show potential, and Caterpillar and Westport have announced a joint venture to power off-road heavy equipment with natural gas. But, commercial production of the vehicles is not planned to start for another five years.

All told, while favorable pricing supports the greater use of natural gas in transportation, unless major investments are made in refueling infrastructure, it is likely to be limited to niche markets.

Potential for LNG Exports

Given the huge disparity between U.S. prices and global prices, the most obvious use for America's future surplus of natural gas is to export it abroad (see Chart 8). While the U.S. is still a net importer overall, it exported about 7% of its production through pipelines to Canada and Mexico. The U.S. government projects that the country will be a natural gas exporter on a net basis in ten years. Increasing natural gas exports would require greater use of liquefaction or LNG (for liquefied natural gas). There are several LNG export projects planned, typically involving converting existing LNG import terminals to handle exports. So far only Cheniere's Sabine Pass project has received approval to export LNG, and it is expected to begin shipping in late-2015. There is vocal opposition in some quarters to exporting natural gas, on worries it would drive up prices domestically.

Recent cost-benefit analysis shows that allowing exports would have significant benefits to the United States[4]. It seems unlikely that all of the proposed projects will ultimately go ahead, and the analysis is based on expected LNG exports of about 10% of total domestic production. Benefits include a gain of approximately $4 billion annually from overseas sales and increased natural gas production, generating jobs in the sector. It could also help displace coal-fired power overseas. These benefits are expected to outweigh somewhat higher domestic natural gas prices, whose distributional effects could be mitigated and any environmental consequences of higher production, which could also be mitigated through stringent regulations.



However, the U.S. is not the only LNG player. Australia is investing heavily in LNG, Canada has proposed LNG terminals and there are already big players like Qatar. Due to costs of liquefaction and transportation ($4/MMbtu to Europe and $6 to Asia) exports would only remain economic if the oil-linked pricing structure of natural gas in Europe or Asia does not change. If natural gas market dynamics shift overseas, lowering the price of natural gas, it could eliminate the U.S. cost advantage for natural gas and the incentive to export over the longer term.

Uncertainties to the outlook for natural gas – engineering & regulatory

If there's one thing the shale gas revolution in North America teaches us, it's that forecasts for resources and relative prices can change dramatically in a short period of time. Production of shale gas is still in its infancy and so there is a considerable amount of uncertainty about how much natural gas is available in the various "plays", which will shape the trajectory of future production. The Marcellus formation, in particular, is so large only small parts of it have been production tested, creating considerable uncertainty over its long-term productivity. The EIA estimates the range on shale gas production could be between 9.7 trillion cubic feet and 20.5 trillion cubic feet in 2035, while total natural gas production is projected to range between 26.1 trillion cubic feet and 34.1 trillion cubic feet, no small deviation.

The other uncertainties about future production fall under the regulatory category. First, the chance that negative public opinion could curtail "fracking" by pressuring regulators to put moratoriums on production. It is already very unpopular in many areas, which results in restrictions on development. There is a high degree of public concern over the impact of "fracking" both on the local environmental and negative effects of industrial development in traditionally non-industrial areas (traffic, noise etc). Like any resource extraction, there are environmental risks associated with shale gas production. Fracking uses large amounts of water in the drilling process, a large concern in areas of the country where water is scarce.

The fluid used in hydraulic fracturing also contains potentially hazardous chemicals, which, if mismanaged, poses the risk of contamination to surrounding areas. The combination of the two means there is a large amount of potentially dangerous waste water produced during the drilling process that needs to be properly treated and disposed. Experts in the field agree that the risks can be mitigated with appropriate regulations and enforcement, and that the costs of these regulations will not be prohibitive to the industry. But, the risks if industry and government don't get the regulations right are high.

Second, the potential for carbon emissions to be regulated or priced will affect future production. While natural gas is better on that score than coal or oil, it is still a carbon-emitting fossil fuel, and a price on carbon would shift the economics of natural gas versus non-carbon based fuel sources. But, given natural gas' relatively lower carbon footprint, the EIA's scenarios under a $15 or $25 carbon price still show increased adoption of natural gas in the power sector.

Bottom Line

The dawn of shale gas production has already turned the North American gas market on its head, reversing stagnating domestic production, resulting in lower prices. These lower prices have benefited consumers directly through lower heating costs and indirectly through smaller electricity bills. It is also shifting the economics in certain industries such as chemical production and power generation. These not only have economic benefits, but in many cases are a favorable outcome for the environment, as natural gas displaces other higher-emitting energy sources. In regions and industries with high exposure to natural gas, benefits will likely be material.

Leslie Preston, Economist
416-983-7053

James Marple, Senior Economist
416-982-2557

Endnotes

1 IHS Global Insight "The Economic and Employment Contributions of Shale Gas in the United States" December 2011

2 Ibid.

3 "Seismic Shifts: The Changing World of Natural Gas" Michael Cleland, The Canada West Foundation, July 2011.

4 "A Strategy for U.S. Natural Gas Exports" Michael Levi, The Hamilton Project, June 2012