CIRCUMSTANCES INFLUENCING THE DEVELOPMENT AND END-USE OF NATURAL GAS FROM SHALE FORMATIONS IN THE UNITED STATES

Mitchell T. Baer  
Director, Office of Oil and Gas Analysis  
Office of Policy and International Affairs  
U.S. Department of Energy

ABSTRACT

As a result of the expanded exploration, development and production of natural gas from the shale gas formation across the US have led USGS and EIA to greatly increase the likely production volumes from these formations. The expanded production has led to considerable interest in domestic uses of the natural gas and export opportunities in the form of LNG. The growing list of regulatory, programmatic, legislative and public challenges to the continuing exploration, development and production of natural gas from the shale gas formations across the country and the export of the gas through LNG may have significant implications for these export opportunity. This paper will explore the most prominent challenges to this export option for the produced shale gas.

INTRODUCTION

Public policy is developed and implemented at several levels of government: local, state, regional, national and international levels. There are many public issues that transcend all of these levels, energy issues are some of the most critical and controversial ones. The Energy Information Administration is projecting that United States natural gas development from both conventional reserves and the emerging unconventional formations will increase substantial over the analysis period for the lastest Annual Energy Outlook (to 2040) to the extent that domestic production will exceed domestic consumption some time during this decade and the production will exceed consumption by at least 5 percent by 2040. This development offers the collective governmental units a unique and one-time-in-a-lifetime opportunity to affect not only the natural gas sector, but the entire energy sector, and not only the energy sector but many other sectors within the economy, including residential, industrial, power, commercial and motor source sectors, as well as the trade sector of the nation through their individual and collective policy-making actions in this area. The policy discussions implemented will have substantial near-term ramifications as well as significant long-term consequences for the trajectory and mix of energy resources in the United States.

But, on a parallel sets of tracks, there are other potential players, voices and conditions, domestic and international, that could influence the trajectory of the shale boom (in both oil and natural gas), both here in the United States and, if the data and assessments are correct, in many countries worldwide. These include the public acceptance of this new form of energy development, the composition and configuration of the shale fields, the growing concern of the environmental impacts of this form of energy development and the larger environmental issues the global countries are now or will in the future have to grapple with, including climate, economy activity, trade and other environmental issues.

EIA PROJECTIONS OF UNITED STATES ENERGY SUPPLY, CONSUMPTION AND END USES

1 Principally the shale formations in Eastern and South Central United States.
2 EIA forecasts of domestic natural gas production have steadily increased during the past 5 years as the technology to extract and the production from the shale formations have produced larger and larger resource estimates. See recent editions of the Annual Energy Outlook at the EIA web site (www.eia.gov/analysis) and see the United States Geological Survey resource estimates for additional information (http://energy.usgs.gov/OilGas/AssessmentsData/NationalOilGasAssessment/AssessmentUpdates.aspx).
EIA projections for the 2012 Annual Energy Outlook provide insight on the past and projected trends in energy use in the United States, in general and specific to certain fuel types. EIA has also conducted an assessment of shale gas reserves in 32 countries throughout the world.

- Figures 1 and 2 are two representations of U.S. energy supply and end uses for 2010. Figure 1 also shows the flows of energy types to the end uses and indicates the percentages of each energy type for each end use.

- Figure 3 presents the historic contributions and projected shares of total U.S. energy supply from the basic energy categories. EIA projects a decline in the share of oil and other liquids over the period of its assessment (to 2035), an increase in the share of renewable energy resources and a steady contribution from natural gas. Early results from the 2013 Annual Energy Outlook indicate the continuing decline in the share of oil and other liquids over the period of its assessment (to 2040), and a continuing increase in the share of renewable energy resources, and an increase in the share of natural gas in the energy mix for the country.

- Figure 4 presents the historic and projected supply categories and shares for natural gas. Note the substantial increase in the projected share to the supply from shale gas resources, an acknowledgement and expectation that the current and past decade of increased production from the shale formations in the United States is projected to continue into the foreseeable future.

- Figure 5 presents EIA’s assessment of the domestic supply of natural gas and its consumption in the United States over the next 25 years and indicates best on the organization’s modeling assessments, the country will produce more natural gas than it consumes some time within the next decade. This projected crossing of the two lines has been projected for earlier time ranges over the past few iterations of the AEO and the 2013 AEO assessment continues to confirm this eventual crossover of the United States from a net importer of natural gas to a potential supply surplus in this resource.3

- Figure 6 presents the projected contribution of natural gas into a key growing end use for this fuel: the electric utility sector. Figure 7 compares the growing role of natural gas projected in the electric utility sector as the projected contribution from coal declines over the next 25 years.

- Figures 8 and 9 present EIA projections of the price of natural gas through its assessment period from the 2009 AEO to the 2012 AEO, again acknowledging the growing projected availability of natural gas from the shale formations and fields.

3 The information in these two figures provides a unique opportunity for the country: the projected excess of natural gas allows its use in a array of existing and prospective end uses. The current and prospective end uses will be discussed in the next section of this paper.
Figure 1: U.S. Energy Supply and End Use

2010 total U.S. energy use = 98.0 quadrillion Btu

Primary energy demand by fuel
- Nuclear: 8.6%
- Petroleum: 36.7%
- Natural gas: 25.2%
- Coal: 21.3%
- Renewable: 8.2%

Primary energy demand by sector
- Electricity - Industrial: 10.4%
- Electricity - Commercial: 14.3%
- Electricity - Residential: 15.6%
- Residential and Commercial: 11.2%
- Industrial: 20.4%
- Transportation: 26.1%

Source: EIA, Annual Energy Outlook 2012 Early Release

Figure 2: U.S. Energy Supply and End Use
Figure 3: U.S. Energy Supply Projections

Fig. 4: Natural Gas Supply
Figure 5: Natural Gas Supply

Figure 6: Natural Gas End Uses
Figure 7: Generation of Electricity

Figure 8: Natural Gas Price (AEO 2011)
EIA has also completed an initial assessment of the shale gas resources in 32 countries outside of the United States. A map of the countries and basins assessed in the study is presented in Figure 10. The assessment concluded:

- There are several countries that currently produce natural gas and have large resource estimates of shale gas (United States, Canada, Argentina, Mexico, China, Australia, Libya, Algeria, and Brazil) and could produce significantly more natural gas in the future.
- There are several countries that currently are dependent on imports of natural gas, but have significant resource estimates of shale gas relative to their current production/consumption balance (France, Poland, Turkey, Ukraine, Chile, Morocco, and South Africa) and could produce more natural gas in the future to narrow or eliminate their import requirements.

THE GROWING OPPORTUNITIES FOR END USES OF NATURAL GAS, CURRENT AND PROSPECTIVE

Natural gas is currently consume as either a raw material for industrial production of finished products (such as in the fertilizer sector) or a fuel in providing power, residential space heating and cooling, cooking, and water heating, or in industrial processes for drying and process production. There is a very limited application of natural gas in the motor vehicle/transportation sector, either as a direct fuel or as a raw material for the production of a liquid fuel. Most of this use of natural gas is in centrally-funded metropolitan-based motor vehicle fleets, such as delivery vehicles and buses. The use of natural gas in the electric utility sector is a growing end use, as environmental regulations and considerations encourage the substitution of natural gas where coal and oil were previously employed.

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Prospective end uses have broadened with the prospective increase in domestic shale gas resources. More projects are being considered to use natural gas as a primary fuel in privately-owned motor vehicle or by converting it over a liquid fuel which would be a substitute for gasoline. Expansion into long-haul truck fleets, additional metropolitan-based motor vehicle fleets, railroad locomotives, off-road construction vehicles, marine applications and cruise ships have been proposed and pilot/demonstration programs are currently underway. Greater use of natural gas in residential applications, including the replacement of home heating oil and electricity in space and water heating and cooking areas. The expansion in the electric utility sector is currently underway and could be expanded and the industrial applications of natural gas, as a feedstock or for heating/power requirements have also been mentioned. Finally, the export of natural gas as liquefied natural gas has been proposed. The Department of Energy has approved one application for the export of natural gas as LNG by Cheniere through its Sabine Pass facility which would be converted from a LNG regasification (import) facility to a liquefaction (export) facility. The Department of Energy is now also considering over a dozen applications for the export of natural gas as LNG from new or converted facilities along the Atlantic, Gulf of Mexico, and northwest Pacific coasts. 

SHALE RESOURCES, OIL AND NATURAL GAS, IN THE UNITED STATES AND NORTH AMERICA

Figure 11 presents a map of North America showing the major shale fields. As with the traditional oil/natural gas fields and production, most of the shale formations produce both oil and natural gas, although the proportions vary and some fields are more predominantly liquids producers and some are more predominantly gas producers. For example, the eastern (Marcellus) and Texas (Barnett) shale fields produce predominantly gas and the upper Mideast (Bakken) shale fields produce predominantly liquids. Shale oil and natural gas field development and production processes (commonly called “unconventional”) differ fairly

*For more information, see the DOE Office of Fossil Energy web site: http://fossil.energy.gov/programs/gasregulation/*. 
substantially from the development and production of conventional oil and natural gas field resources, as seen in Figure 12. Conventional development and production is more commonly known and recognized: a drilling derrick is raised, drilling penetrates an oil and natural gas field and natural and then artificial pressure is applied to produce the resource. For shale natural gas or oil development and production a central primary borehole is drilled, off of which secondary boreholes are drilled, most times in horizontally or near-horizontally directions, into the shale formation. The formation is “fracked” and a fluid is forced into the formation to release the oil or natural gas which is then withdrawn to the surface. Once the length of the secondary borehole is completely “fracked” and produced, a new secondary borehole is drilled and produced. In this fashion, a single centrally-drilled primary borehole can lead to the production for many secondary boreholes. In essence, shale oil and natural gas production is an industrial process, a continuous process, under the oil or natural gas or both resources are completely produced. Instead of having multiple drilling derricks and pumping stations at the surface, which is the traditional way to produce conventional oil and natural gas fields (and is the standard notion of oil and natural gas development and production as understood by the public and portrayed in the movies), shale oil and natural gas development and production occurs from one centrally-positioned drilling site with multiple underground secondary boreholes.

Figure 11: Shale Plays in North America

Source: U.S. Energy Information Administration based on data from various published studies.
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THE SHIFTING AND EVOLVING CIRCUMSTANCES INFLUENCING SHALE DEVELOPMENT IN THE UNITED STATES

Although there are other influences on the pace, expansion, and volume of shale resource development in the United States, either for oil or natural gas development and production, the three major ones are governmental actions at all levels of governments and by all branches of government, the public perception and acceptance of this development, and the infrastructure to transport the products from the fields to the refining and processing facilities and to end use markets.

Mixed and Overlapping Government Jurisdiction or Government Branch Oversight and Regulation. The development of shale resources or the related processing facilities and infrastructure to refine or process its oil and natural gas and transport these finished products to markets are subject to the policies, regulations, studies, public hearings, initiatives, referendums, legal rulings, and laws of several levels of government (local, regional, state and national) through the three branches of government (executive, legislative and judicial) and through grassroots efforts and petitions. Oversight, monitoring, enforcement and regulating occur at all levels of government. In some cases this mixed and overlapping set of oversight responsibilities can lead to delays or denial of necessary permits to explore for, to develop or to produce and transport shale resources to markets.

Infrastructure. As noted in Figure 11, the principal regions of the current development of natural gas from shale reserves (the Marcellus field) and oil from shale reserves (the Bakken field) are located significant distances from existing refining and processing facilities and from the principal markets for oil-related products and natural gas consumption. The Barnett field in Texas is situated in the middle of some metropolitan areas (Dallas/Fort Worth), is an exception, but the development of this field is a principal example cited when the challenge of public perception and acceptance of this form of natural gas development is mentioned. Most of the oil being produced from the Bakken field in North Dakota is being
shipped out of that region by rail car and much of the natural gas from the development in this region is being flared, not transported to markets, due to the lack of adequate infrastructure.

Public Perception and Acceptance. A major challenge facing the further expansion of shale oil and natural gas development is the public perception of the sector and public acceptance of the development. This does go hand-in-hand with an acceptance by industry of its responsibilities to meet the public halfway through public disclosure, education, and engagement. Part of this challenging influence is that some of the development is occurring in frontier areas for oil and gas development (such as North Dakota and New York) where there is no history of natural resource development of oil and natural gas. Part of this challenging influence is that some of the development is occurring in areas that have seen prior oil and natural gas development, but not by the current practices (Texas) or within the collective recollection of the affected publics (Pennsylvania\(^6\)). Part of this challenging influence is the mis-alignment of the surface property rights with the underground mineral rights (as is the case in Texas and the source of conflict in the Dallas/Fort Worth area) where drilling has occurred close to suburban communities. Part of this challenging influence are the potential and in some cases, realized environmental impacts associated with development activities (drinking water quality, surface water contamination, air quality concerns, fugitive emissions of methane (a powerful greenhouse gas), and noise and traffic concerns.

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\(^6\) Remember, Titusville, Pa was the first place that drilling for oil and gas occurred, when Drake drilled and discovered oil there in the 19\(^{th}\) century.