The Unconventional Oil and Gas Boom

BY R. ANDREW BAUER

A dramatic shift is taking place in the U.S. energy sector. For decades, analysts and policymakers assumed that as U.S. reserves of oil and natural gas dwindled, domestic production would decrease gradually and imports would increase steadily. But technological advances in extracting oil and natural gas along with higher energy prices have changed those assumptions. U.S. energy production has risen sharply in recent years and is expected to continue to grow at remarkable rates in coming decades — with benefits for the U.S. economy overall as well as within the Fifth District.

One of the most active regions is the Marcellus Shale, which underlies most of West Virginia, western Maryland, and parts of Ohio, Pennsylvania, and New York. The Marcellus Shale is a rock formation located deep beneath the earth's surface that contains vast amounts of natural gas. West Virginia and Pennsylvania have been actively encouraging the development of this resource in recent years, and the growth in production and the impact on local economies has been tremendous. In December 2013, the Marcellus region provided 18 percent of total U.S. natural gas production — a remarkable increase from almost no production just six years earlier. For the local communities at the epicenter of this production boom, the demand for workers and housing has jumped to the point where both are often in short supply. While this transformation of the energy sector is still in its early stages, the potential long-term impact on the regional and national economy is expected to be considerable.

There are a number of concerns surrounding the oil and natural gas boom, particularly its potential effects on the environment and nearby communities. The sector would face regulatory challenges if research indicated that current methods of production create substantial health or environmental risks. The potential benefit of these resources is so great, however, that additional regulations would likely only slow development in the sector.

Unconventional Oil and Natural Gas

The U.S. energy boom is due to the development of "unconventional" oil and natural gas. Unconventional refers to the fact that the oil and gas are trapped in rock formations with very low permeability and alternative methods are needed to extract them. Examples include "tight oil" and "tight gas," which are found in rock formations such as siltstone, sandstone, limestone, and dolostone; shale gas, which is natural gas found in shale, a fine-grained sedimentary rock with very low permeability; and coalbed methane, which is natural gas found in coalbeds. All of these hydrocarbons are extracted in ways that differ from "conventional" wells where the oil and natural gas naturally flow or can be pumped from an underground reservoir to the surface.

Three factors came together to make production of unconventional oil and natural gas economically viable: horizontal drilling, hydraulic fracturing, and increases in oil and gas prices. While horizontal drilling and hydraulic fracturing are not new, significant technological advances in recent decades have allowed developers to better target and more efficiently extract the oil and natural gas. The process of horizontal drilling and hydraulic fracturing (commonly referred to as "fracking") is more expensive than drilling a conventional vertical well, but higher prices for natural gas have made these techniques economically viable. At some of the early unconventional formations (or "plays"), such as the Barnett Shale in Texas or the Bakken formation in Montana and North Dakota, it wasn't until the mid-2000s, after energy prices rose sharply, that there was more widespread usage of horizontal wells and hydraulic fracking. In the Barnett Shale, one of the nation's most developed shale plays, the number of producing horizontal wells rose from less than 400 in 2004 to more than 10,000 in 2010.

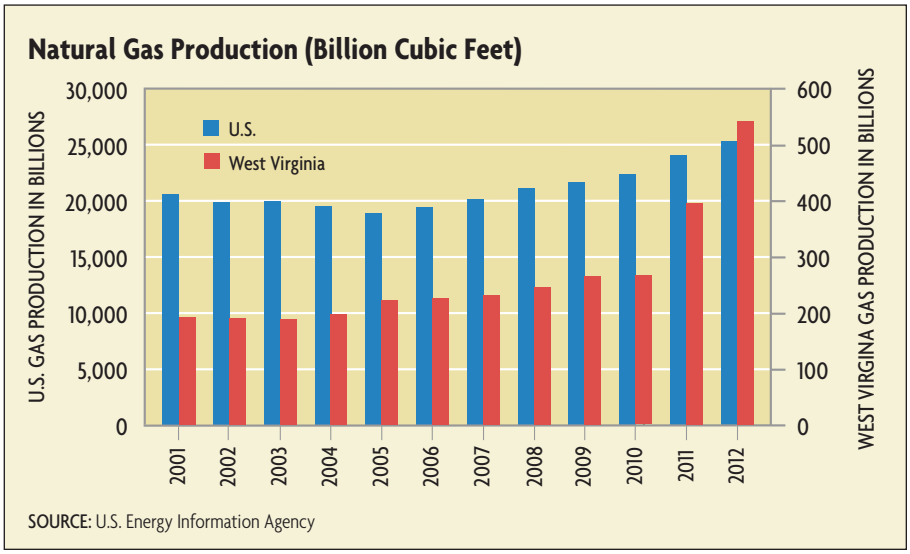
So what exactly is fracking? Fracking involves injecting fluids into rock formations to create fractures in the rock that allow the oil and natural gas to flow through the well to the surface. A horizontal well that utilizes fracking techniques is dug in several stages. The well is drilled vertically to a predetermined depth, depending on the depth of the rock formation, and then the well is "kicked off" or turned at an angle until it runs parallel within the reservoir. The well can extend up to three miles through the reservoir, allowing for a greater number of access points. In drilling the well, several casings are cemented into place to provide stability and to ensure that the fracking fluids and the hydrocarbons do not escape into the surrounding soil.

There has been a lot of controversy surrounding fracking, particularly about its potential impact on the environment. There are concerns that the oil and gas could pollute the groundwater through faulty well design or construction or through migration to the surface. In addition, there are concerns about the fracking fluid used in the process. Fracking fluid is roughly 98 percent water and sand, but the chemicals it contains could pollute drinking water if released. Faulty well design or construction could result in the fluid escaping into the surrounding environment. Improper handling of the fluid that returns to the surface through the well is another issue. This fluid is injected into disposal wells that are thousands of feet underground, but there are concerns that the fluid could migrate upward into groundwater.

There are also concerns related to fracking and earthquakes. According to the U.S. Geological Survey (USGS),

fracking causes earthquakes that are typically too small to be noticed. The USGS has found, however, that the injection of wastewater into disposal wells has the potential to induce larger earthquakes. Of the 40,000 disposal wells in the United States that are related to oil and gas activities, there were roughly a dozen cases where larger earthquakes were detected. The USGS is currently researching the issue to better identify induced earthquakes, understand why they occur in some places but not in others, and determine what should be done once they occur.

Another issue is the amount of stress placed on nearby towns and cities, which typically experience increased traffic, greater use of local water resources, and more air and noise pollution.



SOURCE: U.S. Energy Information Agency

Overall, while there are risks and concerns, there does not appear to be an inherent problem with this particular method of energy extraction. In 2004, the Environmental Protection Agency (EPA) published the results of a study on hydraulic fracturing used in coalbed methane reservoirs to evaluate the potential risks to underground sources of drinking water. The study focused on coalbed methane reservoirs because they are typically closer to the surface and to underground sources of drinking water. The EPA concluded that "the injection of hydraulic fracturing fluids into [coalbed methane] wells poses little or no threat to [underground sources of drinking water]." In 2012, in response to persistent environmental concerns about the surge in fracking, the EPA began a new study to "understand the potential impacts of hydraulic fracturing on drinking water resources." The agency will release a report for peer review and comment in 2014.

The Boom in Unconventional Production

The boom in unconventional oil and natural gas production is expected to increase in coming years. U.S. tight oil production has increased from under 500,000 barrels per day in 2008 to over 2.5 million barrels in 2013. Total U.S. crude oil production increased from 5 million barrels per day in 2008 to 7.4 million barrels per day in 2013, a 49 percent increase. The U.S. Energy Information Agency (EIA) is forecasting production to reach 9.6 million barrels per day in 2015 -- which would match the record U.S. production level reached in 1970. As these formations are slowly exhausted, production is anticipated to then gradually decline in subsequent decades to 7.8 million barrels per day in 2040, slightly higher than 2013 production levels. Notably, as these plays are developed, additional supplies are being found, resulting in sharp increases in proved reserves. Proved oil reserves increased from 19 billion barrels in 2008 to 26.5 billion in 2013, an increase of 39 percent.

The outlook for natural gas is even more astounding (see chart). U.S. shale gas production increased from roughly 1 trillion cubic feet (tcf) in 2006 to more than 8 tcf in 2012. The EIA expects this trend to continue. Shale gas production is expected to reach 17 tcf by 2040. As a consequence, total natural gas production is forecast to increase from roughly 24 tcf in 2013 to more than 33 tcf in 2040. And as was the case with oil reserves, proved natural gas reserves increased sharply in recent years, from 200 tcf in 2004 to 350 tcf in 2013 — an increase of 75 percent in less than a decade.

With the increase in oil and natural gas production, U.S. energy imports have declined sharply. In 2013, U.S. net energy imports were the lowest in more than 20 years. With an abundance of natural gas, the EIA forecasts the United States to become a net exporter of natural gas in 2015. Total U.S. energy consumption is expected to continue to outstrip total U.S. energy production in coming decades, however, mostly as a result of domestic demand for petroleum outweighing domestic production. Yet the gap between production and consumption is expected to narrow considerably. Total energy production is forecast to satisfy all but 3 percent of total consumption by 2034 — a significant improvement from a 16 percent gap in 2012.

Economic Benefits of the Boom

The benefits from greater U.S. production of oil and natural gas are expected to be extensive and long-lasting. There already has been strong growth in the energy sector from increased extraction, distribution, and refining. Much of that growth has been centered in the regional economies where there is active exploration and extraction. In many of the areas where there are active shale plays — including parts of North Dakota, Montana, and Texas — unemployment rates are among the lowest in the country.

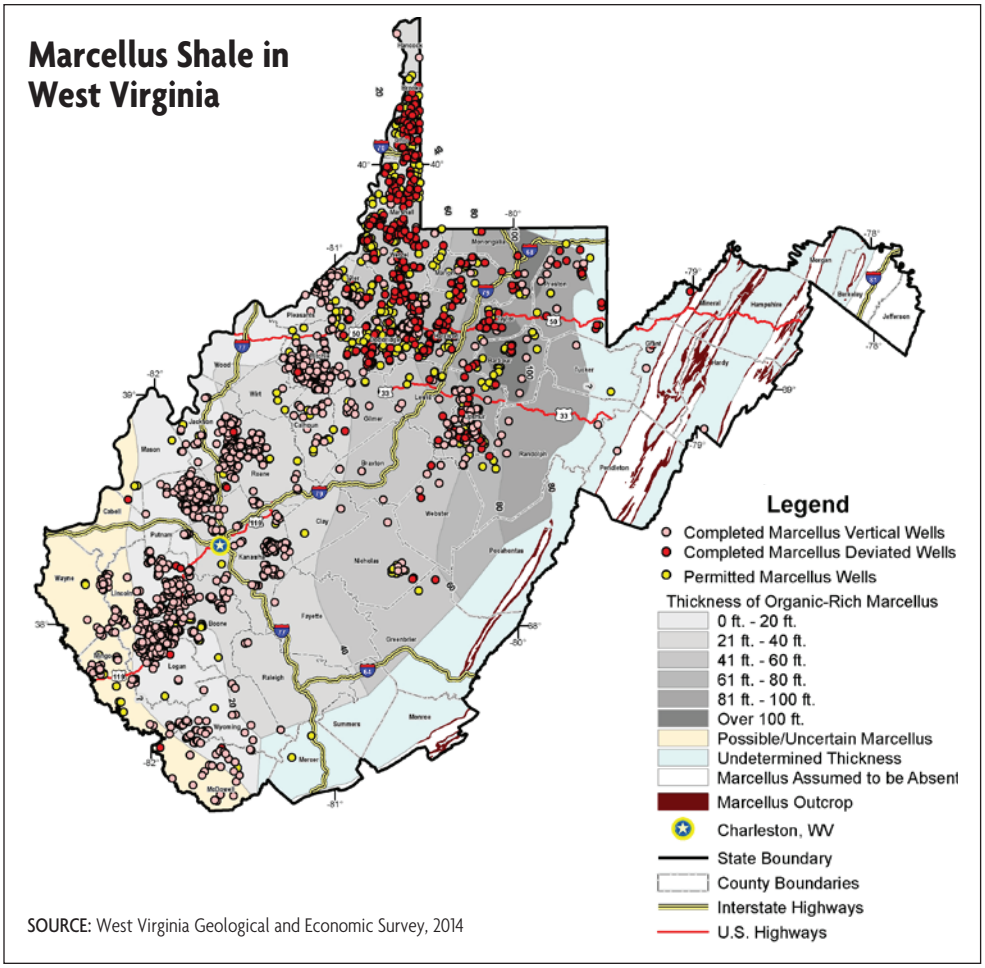
The benefits from energy extraction are not limited geographically, however. Many upstream and downstream industries located across the country have benefited, including the fabricated metal industry, pipe manufacturers, machining industry, oil and natural gas equipment manufacturers, and truck and construction equipment manufacturers.

The production boom in natural gas in recent years also has resulted in lower natural gas prices. The price of natural gas in the United States averaged $3.76 per 1 million Btu (British thermal unit) over the past three years, compared with $10.15 in Europe and $13.88 in Japan. According to the EIA, nearly half of household energy consumption in 2009 was in the form of natural gas while roughly 30 percent of energy consumption in 2010 in the manufacturing sector was natural gas. In addition, 27 percent of electricity was generated using natural gas in 2013 — a percentage that has been increasing in recent years as electrical power companies have been switching away from coal in favor of natural gas by converting old coal-fired units to natural gas ones, shutting down coal-fired plants, and expanding capacity at existing natural gas plants or building new ones. Lower natural gas prices result in lower costs to generate electricity and lower electricity prices that benefit consumers, businesses, and manufacturers. Manufacturers in energy-intensive industries such as refining, iron and steel, cement, food, and chemicals stand to gain even greater benefits from lower electricity costs.

Energy-related chemical industries are also likely to benefit greatly from the boom in natural gas production. Natural gas liquids such as ethane, propane, and butane (known as associated gas or "wet gas") are found in some natural gas reservoirs. These liquids are key chemicals that are used widely in a number of manufacturing industries. Ethane and propane can be processed into ethylene and propylene, which are found in a myriad of consumer products including food packaging, bottles, trash bags, toys, tires, carpets, insulation, and clothing, as well as in construction materials such as siding and PVC. Natural gas or natural gas liquids are used to produce ammonia, plastics, fibers, pesticides, dyes, and other chemicals, as well as many household cleaning solutions. Greater production of natural gas and natural gas liquids have resulted in lower prices for these key chemical components. Given the disparity between natural gas prices in the United States and the rest of the world, chemical manufacturers in this country are likely to enjoy a cost advantage against their overseas competitors.

The Natural Gas Boom in the Fifth District

The Fifth District has experienced the oil and gas boom in recent years as a result of the Marcellus Shale in West Virginia (see map). The natural gas sector has seen a dramatic increase in production in recent years, and those areas of the state where most of the exploration and production is taking place have seen a significant pickup in economic activity, including business creation and job growth. In addition, given the importance of natural gas and natural gas liquids to the chemical industry, the higher output of natural gas may drive additional investment in chemical production, which, in turn, would attract additional manufacturers to the state.



SOURCE: West Virginia Geological and Economic Survey, 2014

Natural gas production in West Virginia increased 140 percent between 2006 and 2012. It rose by 39 percent in 2012 alone, in part due to infrastructure improvements that allowed producers increased access to markets. Within the Marcellus Shale, the number of producing wells rose from 19 in 2006 to over 1,250 in 2012, and the amount of natural gas produced increased from less than 100 million cubic feet in 2006 to roughly 330,000 million cubic feet in 2012. Although an insignificant contribution to total production in 2006, Marcellus Shale gas represented 62 percent of all natural gas produced in West Virginia in 2012. Over this time period, production from horizontal wells soared from less than 1 percent of total production in 2006 to 84 percent in 2012.

While this is a dramatic increase, most of the new production has come from a relatively concentrated area in the northern

West Virginia Oil & Gas Sector

	Employment				Average Salary (in 2013 dollars)			
	2007	2013	'07 - '13 % change	'03 - '13 % change	2007	2013	'07 - '13 % change	'03 - '13 % change
Total (All Industries)	569,774	564,746	-0.9	4.1	37,697	39,519	4.8	6.5
Oil and Gas Extraction	2,442	2,439	-0.1	40.7	65,553	81,970	25.0	45.1
Support Activities for Oil and Gas Operations	2,496	4,463	78.8	189.8	49,902	68,081	36.4	50.8
Natural Gas Distribution	917	742	-19.1	-29.9	75,181	64,559	-14.1	-11.3
Oil and Gas Pipeline Construction	965	3,247	236.5	356.0	60,889	80,183	31.7	76.5
Total Oil & Gas Sector	6,820	10,891	59.7	115.9	62,881	73,698	17.2	34.1
Oil & Gas: % of Total	1.2	1.9			167	186		

SOURCE: Bureau of Labor Statistics

part of the state. The top natural gas producing counties in West Virginia in 2012 — Harrison, Wetzel, Doddridge, and Marshall — accounted for roughly two-thirds of all Marcellus Shale production. The nearby counties of Upshur, Taylor, Marion, Tyler, Monongalia, and Ohio combined for another 17 percent of production in 2012.

The oil and gas sector has been a source of growth for the state economy with gains in employment, wages, and business establishments (see table). Between 2007 and 2013, total employment in the oil and natural gas sector increased from 6,820 to 10,891, an increase of 60 percent. In comparison, total employment in the state went down by 5,028 jobs, or 0.9 percent, during that period. Within the oil and gas sector, the gains were concentrated in two key subsectors: support activities for oil and gas operations, which increased 79 percent, and oil and gas pipeline construction, which rose to 3,247 jobs from 965 in 2007. Other subsectors within the energy sector saw no growth or experienced a loss, however. Employment in oil and gas extraction was flat over the period, while employment in natural gas distribution declined by 175 jobs, or 19 percent.

Wage growth in the energy sector also outpaced the statewide average. In 2007, the average salary in West Virginia was $37,697 (in 2013 dollars), while the average wage in the energy sector was $62,881, roughly 1.7 times greater. The average wage in the energy sector rose 17 percent from 2007 to 2013, considerably faster than the 4.8 percent increase for the average wage across all industries. And just as employment growth was greatest in support activities for oil and gas operations and oil and gas pipeline construction, average salary growth was greatest in those sectors as well. In the oil and gas operation support sector, the average salary rose 36 percent; in pipeline construction, the average salary rose 32 percent and, at $80,183, was more than twice the state's average salary of $39,519 in 2013.

Similarly, business creation in the energy sector outpaced the overall economy. The number of establishments in the energy sector grew by 30 percent from 2007 to 2013, compared with 2.1 percent for the state overall. And as was the case with job and wage growth, the strongest increases were in support activities for oil and gas operations and oil and gas pipeline construction sectors, up 54 percent and 94 percent, respectively.

While gains in employment, wages, and business creation in the energy sector occurred throughout the state, the northern half of the state saw the greatest benefits. The unemployment rate in West Virginia in 2013 was 6.5 percent, considerably less than the 7.4 for the United States, in large part due to the boom in oil and natural gas. The unemployment rate for the top 10 natural gas-producing counties in the northern half of the state was 5.5 percent, well below the state average.

West Virginia's chemical industry also is expected to benefit from increased Marcellus Shale gas and natural gas liquids production. The West Virginia manufacturing sector has a relatively high concentration of chemical manufacturing, particularly in the resin, rubber, and artificial fibers sector, as well as in basic chemical manufacturing. There are 90 chemical manufacturing establishments in West Virginia, including 45 in basic chemical manufacturing and 11 in resin, rubber, and artificial fibers manufacturing. Many of the largest chemical manufacturing companies in the world have a presence in West Virginia, including Dow Chemical, DuPont, Bayer, SABIC, and Braskem. With the prospect of a steady supply of cheap natural gas and natural gas liquids, additional investment in the chemical industry is expected in the coming years and decades.

Conclusion

The unconventional oil and natural gas boom has reversed the outlook for the U.S. energy sector. Instead of decreasing levels of production and reserves, U.S. energy production has jumped in recent years and is expected to continue to increase, with oil production reaching highs not seen since the 1970s and the United States becoming a net natural gas exporter. Since natural gas is widely used across sectors, the prospect of relatively inexpensive natural gas may translate to broad gains for the U.S. economy. Greater production of natural gas liquids and natural gas, for example, will allow the U.S. chemical industry to enjoy cheaper input costs and a relative cost advantage over its competitors overseas. With the Marcellus Shale in West Virginia, the Fifth District is squarely in the center of this transformation of the energy sector. **EF**