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Is the Natural Gas Revolution all its Fracked Up to Be for Local Economies?

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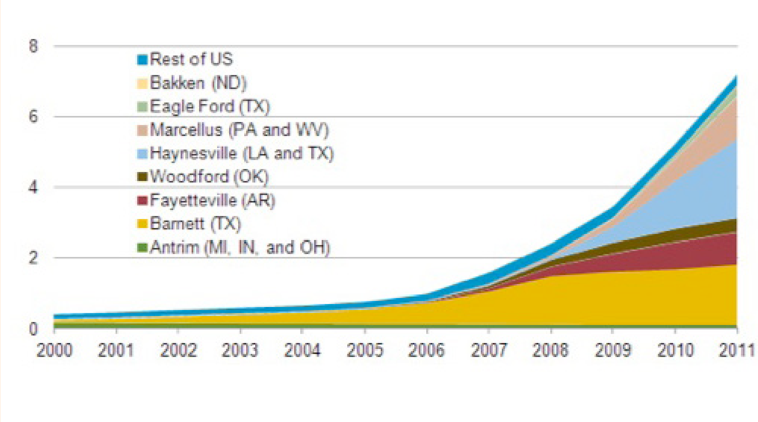
Large-scale development of natural gas and oil from shale has been described as a revolution (*New York Times* columnist David Brooks), a bonanza (*The Economist*), and simply a boom (*Forbes*). Regardless of how this historical event is described, all agree that the magnitude of development is huge with large domestic reserves of shale oil and gas set to reduce U.S. oil and gas imports. The U.S. Energy Information Administration (EIA) e stimates that, at current rates of consumption, the United States has enough natural gas from shale alone to supply the entire country for about 90 years (over 2,400 trillion cubic feet) as well as more oil than previously thought (225 billion barrels) (EIA, 2013). For natural gas, the United States is in the early years of a potentially long expansion in production with the EIA estimating that, by 2040, production of natural gas will double relative to the level in the mid-2000s when drilling in shale became common (Figure 1). Yet, concerns about local consequences of extraction of oil and gas from shale formations have caused several states such as New York and Maryland and many local governments around the country to pass a moratoria on hydraulic fracking, the key technology used to develop shale. This collection of articles aims to increase the understanding of several local consequences of unconventional oil and natural gas development.

Articles in this Theme:

A Brief History of Shale Development

The successful extraction of gas or oil from shale rock stems from two principle technologies—high-volume hydraulic fracturing (also known popularly as "fracking") and horizontal drilling. Despite the recent media attention on the technologies, they are not new in principal. A patent application for equipment designed to drill horizontal wellbores was filed in 1919, and the first horizontal wells were successfully drilled in 1929 (U.S. Geological Survey, 1992). Experiments with fracking occurred in the 1930s, with the first commercial application in 1949 (Montgomery and Smith, 2010). The Morgantown Energy Research Center (a precursor to the National Energy Technology Laboratory) researched hydraulic fracturing as early as the mid-1970s (Lockner and Byerlee, 1977).

Figure 1: Historical and Projected Production of Natural Gas in the United States



Source: U.S. Energy Information Administration, 2012a

The pioneering work of George Mitchell and others, however, would take the two relatively obscure technologies from conversations in geology and petroleum engineering circles to the American public in the first decade of the 2000s. Mitchell's company, Mitchell Energy and Development, experimented with water, sand, and chemical combinations that, when injected into shale, would release the most gas at the lowest cost. Perhaps more importantly, Mitchell combined horizontal drilling with fracking, which dramatically increased the effectiveness of both technologies.

Mitchell is known by some as the "father of [fracking]" for leading his company to experiment with hydraulic fracturing techniques to extract natural gas from shale rock in the Barnett Shale region in Texas. However, Pierobon (2013) attributes much of the success of Mitchell's company to its team of geologists and seismologists led by Dan Steward during the 1980s and 1990s. According to Pierobon (2013), the modern techniques of hydraulic fracturing developed by Mitchell Energy would not have been possible without the backing of George Mitchell, but it was the team led by Steward that developed a relatively simple mix of sand and water, called a "slick water frac," and developed three-dimensional seismic test data by the company's seismologist Kent Bowker.

By the late 1990s, Mitchell Energy's activities still received little attention from the industry or trade press, with the exception of a short, 5,700-word article in the May 1998 issue of *Oil & Gas Journal* mentioning that natural gas had been successfully extracted from the Barnett shale. Otherwise, the company's activities seemed to escape the industry's radar.

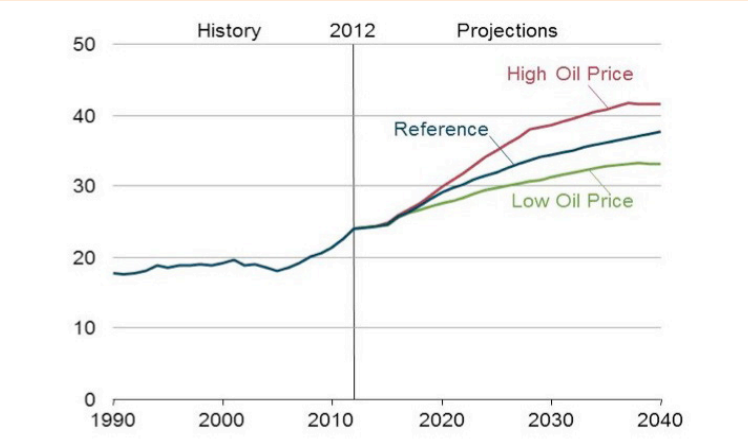
By 2000, Mitchell Energy was seeking additional outside financial support to expand its operations based on its newly developed techniques. One of the potential investment companies included Devon Energy. Mitchell Energy invited representatives from Devon to a secretive, non-disclosure meeting at Mitchell's headquarters and demonstrated its new slick water fracking and three-dimensional seismic imaging techniques. According to Devon Energy's co-founder Larry Nichols, everyone came away from that meeting thinking:

> "Everybody looked at that technology (Mitchell Energy) was developing of hydraulic fracturing and said it doesn't work… It's old, it's tired… there's nothing there. Everyone knows that. Don't waste your time." (Pierobon, 2013)

With talk of Mitchell Energy's efforts growing, however, Devon Energy and Nichols were invited back to Mitchell's headquarters in 2002 and had a different impression. Nichols acknowledged, "We went down there a second time a year-and-half later and discovered it really did work." Shortly thereafter, Devon Energy acquired Mitchell Energy and Development for $3.5 billion, and George Mitchell became Devon's single-largest individual shareholder as part of the deal (Pierobon, 2013).

That meeting between Devon and Mitchell Energy, as it turns out, was a pivotal moment for the natural gas industry. The size of the investment signaled to the rest of the industry that the hydraulic fracturing techniques developed by Mitchell's team were economically viable methods to develop large quantities of the gas trapped in shale. Soon thereafter, additional exploration and production companies began developing natural gas in the Barnett Shale Play and other regions using similar technologies. As shown in Figure 2, shale development was slow after the 2002 meeting, but then expanded exponentially in the mid- to late-2000s.

Figure 2: Estimated Annual U.S. Dry Shale Natural Gas Production, 2000-2011 (trillion cubic feet per year)



Source: U.S. Energy Information Administration, 2012b.

Producing Oil and Gas for 100 Years: Why the Controversy Now?

The current public debate about shale development and its effects may surprise some. The United States has been producing oil and gas for more than a century and has experienced oil and gas production booms before. Why, then, has the current boom spawned so much controversy, prompting moratoria, documentaries, and new activist organizations? The answer has at least three facets.

First, the development of oil and gas from shale formations has reshaped expectations about the supply of fossil fuels for the coming decades at a time when concerns about human-induced climate change are growing. Many see drilling in shale as enabling the United States and others to delay transitioning to a low-carbon, renewable energy economy.

Second, the public interest in shale development reflects, in part, where development is, and will be, occurring. The expected expansion of oil and gas (as indicated by Figure 1 for natural gas) comes from greater drilling not in Alaska's remote North Shore nor miles out in the Gulf of Mexico. Rather, it will come from thousands of wells drilled on private not require the volume of water and sand that current fracking techniques involve. By extension, it did not involve thousands of truckload trips and the noise or dust associated with it. Unlike conventional extraction, hydraulic fracturing produces toxic and radioactive water from a mixture of fracturing fluids and deep saline formation waters. Potential chemical hazards of such include elevated levels of sodium, chloride, calcium, methane, boron, and other higher-chain hydrocarbons (among others) (Osborn et al., 2011).

Why Understanding Local Consequences Matters

Public support for moratoria on fracking, more stringent regulations, or higher taxes on the industry are closely connected to beliefs about local consequences. The potential consequences for people's health, their water and landscape, and the overall quality of life in their communities is what caused over-flow crowds at town hall meetings in New York and elsewhere.

Better information helps policy makers design appropriate policies while a more informed public helps provide the political support for them. Policy debates swayed by unrepresentative, anecdotal evidence will result in real problems being ignored or costly initiatives addressing phantom problems. As mentioned, extraction can involve excessive wear on roads, bridges, and public water systems. Support for measures to raise revenues to address the wear depend on realistic assessments of costs. It took the Pennsylvania legislature until 2012 to begin directly taxing drilling activities through an impact fee on each well drilled. Similarly, prohibition of methods that can be safely used means foregoing the extraction of valuable oil or gas. Foregone extraction means a wealth loss to the resource owner, a foregone source of tax revenue, and depending on the scale, higher energy prices to consumers.

Unfortunately, it is easy for public perception to be swayed by anecdotal evidence. The documentary *Gasland* famously showed a Pennsylvania homeowner lighting on fire the water coming out of his faucet. With its striking visuals and moving personal testimonies, the film brought the water issue to the public's attention, energizing activist movements that engaged many people far removed from places of drilling. Although a picture can tell a thousand words, it cannot answer two important questions: what caused the flammable water in the case in question, and how many cases of the thousands of cases not pictured does it represent?

Yet, there is reason to be optimistic about a growing public understanding of the local consequences of shale development. Prior booms in onshore oil and gas production occurred when health, environmental, and economic data and tools for working with them were very limited. Researchers today, in contrast, have tremendous data at their fingertips, powerful computers, and easy-to-use statistical software to quantify systematic effects of development. In 2014, the county-level oil and gas production data for the lower 48 states was made publicly available. For states like Pennsylvania, databases complete with spatial information are publicly available and allow researchers to know exactly where and when each shale well was drilled. The EIA, in collaboration with the Groundwater Protection Council, is working to create standardized well-level databases for many oil- and gas-producing states. The increased ease of accessing fine-grained data will encourage a proliferation of studies on local impacts to an extent that is incomparable to prior years, the contours of which we outline below.

Local Consequences are Diverse in Nature and Who They Affect

Local consequences can range from low birth-weight babies (Hill, 2013) to economic prosperity (Weber, 2012 and 2014; and Brown, 2014). The distribution of prosperity can be felt unequally among local residents. The case of the Dallas-Fort Worth area is illustrative. The Barnett Shale splits the Dallas-Fort Worth metropolitan region in half and is where high-volume hydraulic fracking and horizontal drilling were first combined and applied at scale. Weber, Burnett, and Xiarchos (2014) document how housing values appreciated more in shale zip codes than in zip codes just outside of the shale. The greater appreciation in part reflects an expansion in the local property tax from an expansion in the value of oil and gas rights, which are taxed as property by local governments and schools in Texas. They show that an improved tax base, in turn, increased revenues to local schools and their per-student expenditures.

The story, however, does not end there. Although housing in zip codes within the shale generally appreciated more than those outside the shale, zip codes with more wells appreciated less than those with fewer wells. The negative relationship between housing appreciation and drilling intensity likely reflects a range of quality of life issues brought on by drilling, including truck traffic, natural gas-related infrastructure on the landscape, lower air quality, noise, and contamination risks to groundwater-dependent homes. Due to the tremendous amount of risk uncertainty, many scientists have advocated for additional testing and research to better understand the mechanism of contamination to groundwater near drilling sites. They call for systematic and independent data collection on groundwater including dissolved-gas concentrations and isotopic compositions prior to drilling operations beginning in a region (Osborn et al., 2011). As such, one can see why local residents have diverse opinions about shale development: the costs and benefits are unequally spread among various groups such as those living near or far from wells, and those with or without subsurface rights.

Our brief description of findings from one study of the Barnett Shale represents the first 100 feet of a mile-deep well with many twists and turns. The articles in this *Choices* theme describe in more detail the salient issues raised by recent and emerging research on local consequences. The first article, by Kelsey, highlights the unique issues facing local governments from shale development, which can generate revenue for local infrastructure, but the frenetic and volatile pace of drilling makes planning for public investments difficult. The second article, by Weinstein, discusses the impacts to employment at both the local and state levels associated with shale development, and highlights how impacts can vary in different contexts. Since much of the current development occurs on farms and ranches, the third article by Hitaj, Boslett, and Weber discusses how development can bring royalty dollars to farmers but also can create more competition for local water resources and employment. The fourth article by Fitzgerald focuses on the distribution of royalty payments to various stakeholders, including private mineral owners. The author finds that energy companies paid more than $30 billion to private mineral owners in 2012 though, in many states, only a small fraction of the payments went to residents living in the county where production occurred. The final article by Olmstead and Muehlenbachs explores the effects of drilling activities on nearby water resources. The authors argue that much of current debate focuses on the impacts to water quality, but much more research is needed to understand the impacts to water quantity as well.

For More Information

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