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# Hydraulic Fracturing: A Game-Changer for Energy and Economies

by Isaac Orr\*

## Introduction

Vast reserves of oil and natural gas have been known to exist in shale formations throughout the United States for decades, but extracting these resources was not economically viable until the advent of “smart drilling” technology—the combination of horizontal drilling, hydraulic fracturing techniques, and computer-assisted underground monitoring.<sup>1</sup> This technology, along with confidence that oil prices would remain high, gave producers the incentive to discover and develop shale and other unconventional sources of oil and gas around the nation.<sup>2</sup>

Hydraulic fracturing, more commonly known as “fracking,” has transformed the way oil and natural gas are produced in the United States. Before hydraulic fracturing became widely practiced, U.S. energy production forecasts were bleak and threatened to exert downward pressure on the economy as a whole.

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For example, in his testimony before the House Energy and Commerce Committee in 2003, then-Federal Reserve Chairman Alan Greenspan warned high natural gas prices were particularly worrisome for industries dependent upon large amounts of natural gas, such as the

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\* Isaac Orr is a research fellow of The Heartland Institute. A more complete bio appears on page 35. He thanks Charles Battig, George Clowes, Ken Dupre, Seldon Graham, Ken Haapala, Jeff Muhlenkamp, Ron Muhlenkamp, William Peirce, Taylor Smith, and Theodore F. Them for valuable comments. Any errors that remain are solely the author’s. The author notes all URLs cited in the footnotes were operational on July 26, 2013.

<sup>1</sup> North Dakota Industrial Commission, “Bakken Formation Reserve Estimates, Executive Summary,” n.d., [www.nd.gov/ndic/ic-press/bakken-form-06.pdf](http://www.nd.gov/ndic/ic-press/bakken-form-06.pdf).

<sup>2</sup> *Ibid.*

chemical, fertilizer, and steel and aluminum processing industries. Greenspan noted, “The perceived tightening of long-term demand-supply balances is beginning to price some industrial demand out of the market.”<sup>3</sup> Greenspan suggested the United States increase natural gas imports from abroad in the form of liquefied natural gas (LNG) to satisfy domestic demand and reduce consumer costs.<sup>4</sup>

Greenspan’s forecast appeared to be accurate as natural gas prices continued to climb in 2005, reaching \$16 per million British Thermal Units (MMBtu) in some production area spot markets due to growing demand and a drop in production resulting from damage to offshore drilling infrastructure caused by Hurricane Katrina.<sup>5</sup>

Thirty-five states now participate in what has been christened America’s Shale Revolution.

Despite these supply problems, 2003, the year Greenspan delivered his pessimistic forecast on the future of natural gas, marked a turning point in the national narrative on oil and gas production when scientists in the Barnett Shale of northern Texas, using the smart

drilling technology developed by George Mitchell in the 1990s, demonstrated that a combination of hydraulic fracturing and horizontal drilling could transform previously uneconomic plays into viable drilling options, and in doing so changed U.S. oil and natural gas supply forecasts from scarcity into abundance.<sup>6,7</sup>

Thirty-five states now participate in what has been christened America’s Shale Revolution. This development has resulted in a 34 percent increase in U.S. natural gas production since 2005, which has made the United States the world’s largest producer of natural gas.<sup>8</sup>

The Shale Revolution also has brought U.S. oil production to a 20-year high and created

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<sup>3</sup> Diane Hess, “Greenspan Discusses Natural Gas Woes,” *The Street*, July 10, 2003, <http://www.thestreet.com/story/10099308/1/greenspan-discusses-natural-gas-woes.html>.

<sup>4</sup> Dan Thanh Dang, “Greenspan Warns of Natural Gas Supply Gap,” *The Baltimore Sun*, June 11, 2003, [http://articles.baltimoresun.com/2003-06-11/news/0306110217\\_1\\_natural-gas-markets-gas-for-heating-supplies-of-natural](http://articles.baltimoresun.com/2003-06-11/news/0306110217_1_natural-gas-markets-gas-for-heating-supplies-of-natural).

<sup>5</sup> Joseph T. Kelliher, “High Natural Gas Prices: The Basics,” Federal Energy Regulatory Commission, December 2005, <http://www.ferc.gov/legal/staff-reports/high-gas-prices-1.pdf>.

<sup>6</sup> Marc Airhart, “The Father of the Barnett Natural Gas Field, George Mitchell,” <http://geology.com/research/barnett-shale-father.shtml>.

<sup>7</sup> Institute for Energy Research, *Barnett Shale Fact Sheet*, 2012, <http://www.instituteforenergyresearch.org/wp-content/uploads/2012/08/Barnett-Shale-Fact-Sheet.pdf>.

<sup>8</sup> U.S. Energy Information Administration, U.S. Natural Gas Marketed Production, June 28, 2013, <http://www.eia.gov/dnav/ng/hist/n9050us2A.htm>.

thousands of energy sector jobs, in addition to thousands of jobs outside the energy sector.<sup>9,10</sup> Last year, U.S. oil production increased by 14 percent over the previous year, the greatest increase among countries annually producing a million barrels or more. The year 2012 also marked the largest one-year increase in oil production in U.S. history.<sup>11</sup> In the process, oil imports as a percent of U.S. consumption have fallen from 70 percent in 2009 to 37 percent in February of 2013, despite policies from Washington that have caused production of oil, natural gas liquids, natural gas, and coal on federal land to fall in quantity and as a percentage of total production.<sup>12,13</sup> Furthermore, North America is projected to become energy-independent by 2020, a development that would have been impossible prior to the invention of smart drilling.<sup>14</sup>

The economic impact of hydraulic fracturing is not limited to the energy sector or the communities near drilling sites. Increased domestic production of natural gas has resulted in lower natural gas prices.

According to the Yale Graduates in Energy Study Group, natural gas consumers saved more than \$100 billion in 2011; the study suggests the overall benefit derived from recovering shale gas outweighs the costs by a ratio of 400 to 1.<sup>15</sup> Inexpensive natural gas is also driving investment in energy-intensive industries such as steel and aluminum processing, fertilizer production, and manufacturing as energy becomes more affordable due to the switch from coal to cleaner and less-expensive natural gas for electricity generation.

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<sup>9</sup> Garry White and Emma Rowley, "Fracking to the rescue as US oil production hits 20-year high," *The Telegraph*, March 4, 2013, <http://www.telegraph.co.uk/finance/commodities/9905821/Fracking-to-the-rescue-as-US-oil-production-hits-20-year-high.html>.

<sup>10</sup> Taylor Smith, "The Benefits of Shale Energy on Other Industries," *Research & Commentary*, The Heartland Institute, March 28, 2013, <http://heartland.org/policy-documents/research-commentary-benefits-shale-energy-other-industries>.

<sup>11</sup> Mark Perry, "U.S. Oil Output in 2012: Largest 1-Year Gain in U.S. History," American Enterprise Institute, June 12, 2013, <http://www.aei-ideas.org/2013/06/us-oil-output-in-2012-largest-one-year-gain-in-us-history/>.

<sup>12</sup> David Blackmon, "The Texas Shale Oil & Gas Revolution—Leading the Way to Enhanced Energy Security," *Forbes.com*, March 19, 2013, <http://www.forbes.com/sites/davidblackmon/2013/03/19/the-texas-shale-oil-gas-revolution-leading-the-way-to-enhanced-energy-security/>.

<sup>13</sup> United States Energy Information Administration, *Sales of Fossil Fuels Produced on Federal and Indian Lands, FY 2003 Through 2012*, May 2013, <http://www.eia.gov/analysis/requests/federallands/pdf/eia-federallandsales.pdf>.

<sup>14</sup> Megan L. O'Sullivan, "'Energy Independence' Alone Won't Boost U.S. Power," *Bloomberg*, February 14, 2013, <http://www.bloomberg.com/news/2013-02-14/-energy-independence-alone-won-t-boost-u-s-power.html>.

<sup>15</sup> Robert M. Ames, Anthony Corridore, Joel Nathan Ephross, Edward Hirs, Paul MacAvoy, and Richard Tavelli, "The Arithmetic of Shale Gas," June 15, 2012, <http://ssrn.com/abstract=2085027> or <http://dx.doi.org/10.2139/ssrn.2085027>.

The United States is the world leader in developing hydraulic fracturing technology and development of shale reserves. State and federal regulators are responsible for developing rules and guidelines to protect the public interest. Every society utilizes natural resources, and doing so will have an impact on the environment. People must weigh the costs of developing the resource against the benefits that would be derived from doing so, and develop that resource in the most environmentally friendly way.

This *Policy Study* has been written to explain the advantages and disadvantages of smart drilling and the alternatives so that a better-informed discussion can take place.

Although stories of economic opportunity are a major focus in newsrooms across the nation, environmental groups have raised concerns about the impact this new technique for oil and gas extraction could have on the environment, including concerns about groundwater contamination, water consumption, wastewater disposal,

earthquakes, and greenhouse gas emissions. Some environmental groups and policymakers have called for increased regulation of the hydraulic fracturing industry, and others have advocated fracking moratoria, such as the one that has been in place in New York since 2008.

Those raising these fears have taken advantage of the public's limited understanding of the smart drilling process, limited knowledge of geology, and lack of knowledge of current federal and state regulations on oil and gas production. This *Policy Study* has been written to explain the advantages and disadvantages of smart drilling and the alternatives so that a better-informed discussion can take place.

In Part 1 of this *Policy Study*, the author reviews the background and potential of hydraulic fracturing in the United States and then puts that potential in the context of the supply of and demand for oil and gas. Part 2 addresses the environmental impacts of hydraulic fracturing, both positive and negative, as well as public safety issues that have been raised by activists, such as potential harm to drinking water supplies. Part 3 discusses how oil and gas production is regulated at the state and national levels and discusses the proper interaction of these two levels of government. Part 4 offers concluding remarks.

This *Policy Study* concludes hydraulic fracturing can be done in a safe and environmentally responsible manner. State governments have done a commendable job working with environmental and industry leaders to craft legislation that protects the environment while permitting oil and gas production to move forward. Federal regulations would be duplicative, resulting in higher costs without significantly increasing environmental protections.

# PART 1

## The Extraction Process

### Conventional Oil and Gas Extraction

Traditionally, oil and gas wells were drilled straight down into permeable, oil- and gas-rich host rocks such as sandstone or limestone, where oil and gas could easily flow through the rock, into the well, and up to the surface.

Think of it as drinking the last of a soft drink from a fast food restaurant. The straw is the well that extends to the bottom of the cup, the beverage is the oil or gas, and the ice is the permeable host rock. The high permeability of the ice allows the soft drink to be sucked out of the cup relatively easily. Although this analogy is imperfect (oil and gas rise through the well due to pressure, whereas the beverage is brought up by a vacuum), it provides a basic understanding of how oil and gas flow through the host rock during the process of conventional drilling.

As production from conventional wells began to decline after 1985, scientists searched for alternative methods of extracting oil and gas. The result was smart drilling.

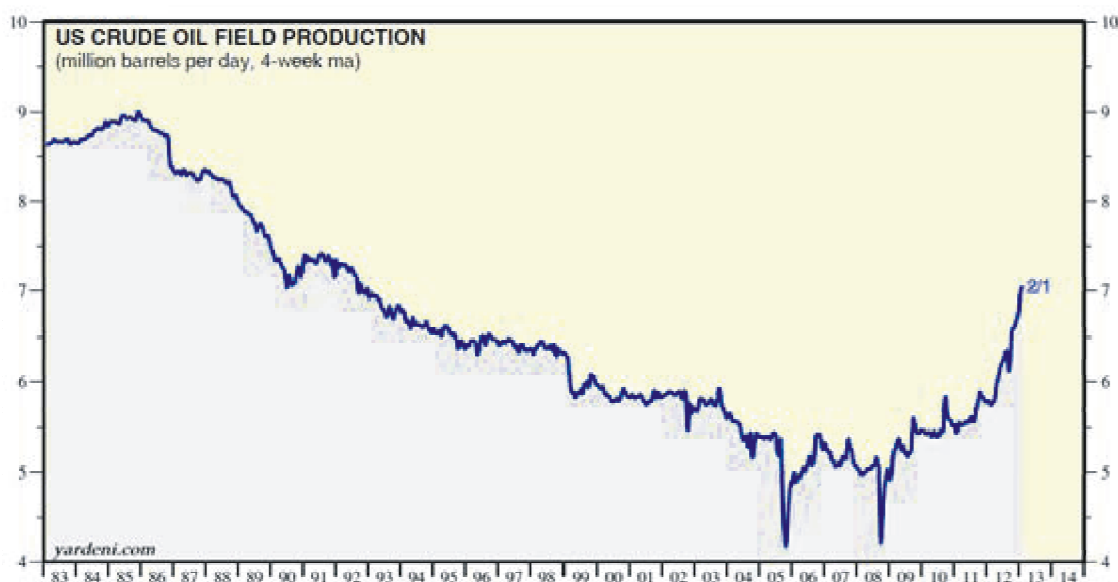
As production from conventional wells began to decline after 1985 (see Figure 1), scientists searched for alternative methods of extracting oil and gas. The result was smart drilling, the combination of hydraulic fracturing and horizontal drilling. Although hydraulic fracturing and horizontal drilling had been used separately to stimulate production at conventional wells since 1947 and 1929, respectively, the combination of these methods has enabled scientists to extract oil and gas trapped in impermeable source rocks such as shale, well-cemented sandstone, and coal bed methane deposits once considered too costly to develop.<sup>16</sup>

Media reports of “fracking” refer to the combination of these two techniques. Throughout this *Policy Study* the author will use the terms hydraulic fracturing, fracking, unconventional energy production, and smart drilling interchangeably to mean the combination of hydraulic fracturing and horizontal drilling, except in the section entitled “What is Fracking?” where the author provides a more detailed explanation of these two techniques and their relation to unconventional energy production.

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<sup>16</sup> U.S. Environmental Protection Agency, *Directional Drilling Technology*, <http://www.epa.gov/cmop/docs/dir-drilling.pdf>.

**Figure 1. U.S. Oil Production 1983–2012**



Following nearly two decades of declining oil production, hydraulic fracturing has reversed the U.S. oil production trend. *Source: U.S. Department of Energy.* According to the International Energy Agency, the United States is projected to become the world's largest oil producer by 2017, surpassing Saudi Arabia. Peg Mackey, "U.S. to Overtake Saudi Arabia as Top Oil Producer: IEA," *Reuters*, November 12, 2012, <http://www.reuters.com/article/2012/11/12/us-iea-oil-report-idUSBRE8AB0IQ20121112>.

## What Is Fracking?

Hydraulic fracturing is the process of breaking up low-permeability oil- and gas-rich source rocks, enabling the oil and gas to flow freely toward the well. It is accomplished by injecting a mixture of water, sand, and chemical additives at extremely high pressures of 10,000 to 15,000 pounds per square inch (PSI) into wells drilled in the source rocks.<sup>17</sup> This mixture, commonly referred to as fracking fluid, is composed of 90 percent water, 9.5 percent sand, and 0.49 percent chemical additives.<sup>18</sup>

The sand, typically referred to as frac sand, is generally well rounded (almost spherical), well sorted (all the grains are generally the same size), and durable (able to withstand compressive stresses of 4,000 to 6,000 psi). The sand acts as a proppant keeping open the fissures created

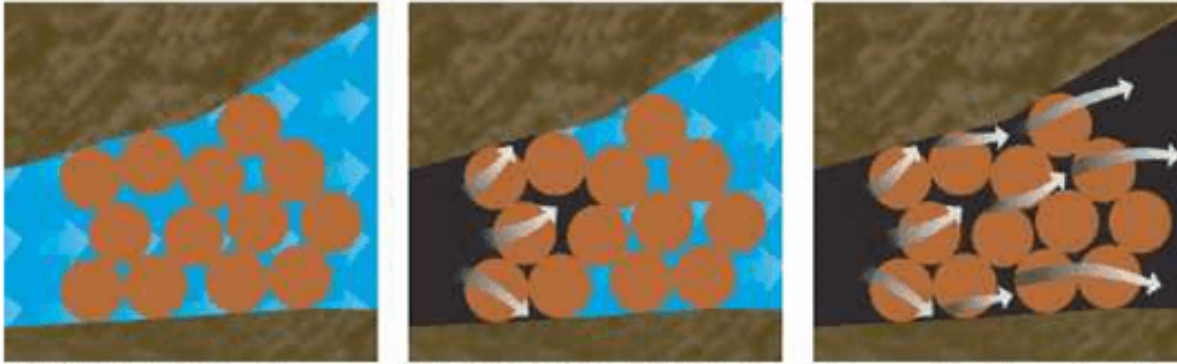
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<sup>17</sup> "Fracking," Marcellus Shale, <http://www.marcellus-shale.us/fracking.htm>.

<sup>18</sup> "Fracking Fluids," Energy From Shale, <http://www.energyfromshale.org/hydraulic-fracturing/hydraulic-fracturing-fluid>.

during the fracking process, increasing the porosity and permeability of the rocks, thus allowing more oil and gas to be recovered (see Figure 2).<sup>19</sup>

**Figure 2. Resource Flow Through Proppant**



Proppant prevents the fissures created during the fracking process from collapsing and allows oil and gas to flow freely to the well. *Source: Image modified from momentivefracline.com.*

### **Fracking Fluid**

Although chemical additives constitute a very small percentage of the fracking fluid, as shown in Figure 3, they serve a wide variety of important functions such as preventing corrosion in the well, reducing surface tension in liquids, stabilizing clay particles, adjusting pH, and eliminating bacteria.<sup>20</sup>

Many of the chemicals used in fracking fluid are found in common household items. Figure 4 shows the category of the chemical, the name of the chemical, its purpose in the well, and where it can be found in your bathroom, laundry room, or garage.<sup>21</sup>

Concerns about the safety of some of these chemicals have prompted the oil and gas industry to undertake two major courses of action: one, increasing the disclosure of the chemicals used in the smart drilling process, and two, in the case of one company, making the chemicals used in fracking fluid nontoxic.

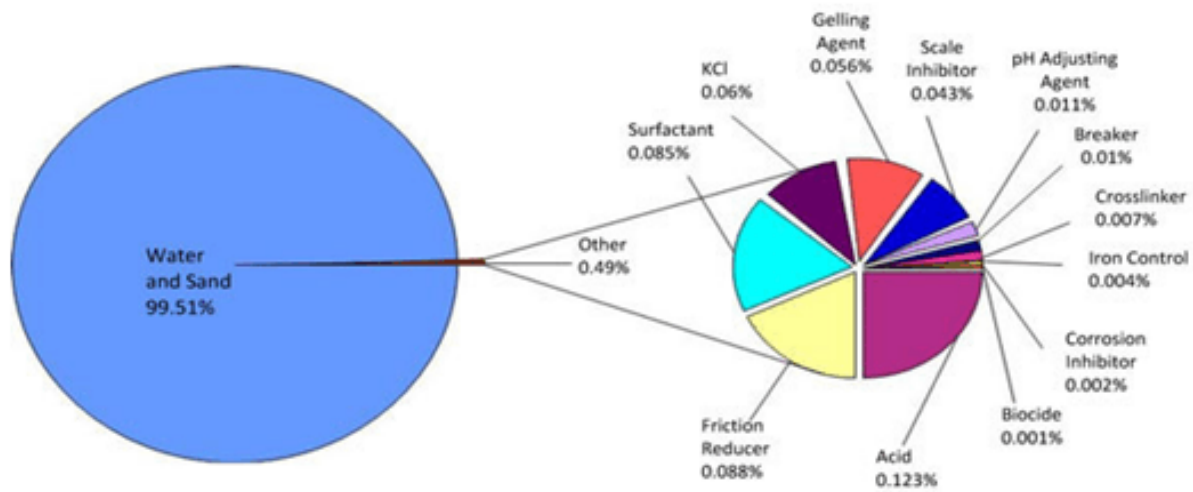
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<sup>19</sup> Mike O'Driscoll, "Frac Sand Frenzy: Focus on Supply & Demand for Hydraulic Fracturing Sand" *Industrial Minerals*, March 2012, <http://www.indmin.com/downloads/MODFracSandFrenzySilicaArabia201213312.pdf>.

<sup>20</sup> P. Kaufman, G.S. Penny, and J. Parktinat, "Critical Evaluation of Additives Used in Shale Slickwater Fractures," *Paper SPE 119900*, Society of Petroleum Engineers, November 2008, <http://www.flotekind.com/Assets/SPE-119900-Critical-Evaluations.pdf>.

<sup>21</sup> United States Department of Energy, *Modern Shale Gas Development in the United States: A Primer*, April 2009, <http://fracfocus.org/node/93>.

**Figure 3. Composition of Fracking Fluid**



Fracking fluid is largely composed of water and sand (90 percent water and 9.51 percent sand). Chemical additives represent just .49 percent. Source: *United States Department of Energy, Modern Shale Gas Development in the United States: A Primer, April 2009, p. 62, <http://fracfocus.org/node/93>*

Chemical disclosure has occurred through Web sites such as Fracfocus.org and its European counterpart, NGSFACTS.org.<sup>22</sup> These Web sites provide the public access to the reported chemicals used in wells in a particular area. Fracfocus.org allows individuals to learn which chemicals are utilized at each specific well in its database, an important feature because the chemicals used vary based on local chemistry, causing them to differ from well to well.<sup>23</sup>

Further responding to concerns that the chemicals in fracking fluid could harm the environment, Halliburton has introduced CleanStim, a new nontoxic mixture of fracking fluid additives consisting entirely of ingredients used in the food industry. Colorado Gov. John Hickenlooper, a Democrat who holds a master's degree in geology, grabbed headlines after he told the U.S. Senate Committee on Energy and Natural Resources that he drank CleanStim and it was a "benign fluid in every sense."<sup>24</sup> It remains to be seen whether entirely nontoxic chemical additives will become widely used in fracking fluid, but as chemical disclosure becomes more prevalent, products like CleanStim have the potential to change the chemical makeup of fracking fluid at wells across the nation.

<sup>22</sup> Alessandro Torello, "New OGP Website Identifies Chemicals Used in Shale Gas Operations," International Association of Oil and Gas Producers, June 18, 2013, <http://www.ogp.org.uk/news/press-releases/new-ogp-website-identifies-chemicals-used-in-shale-gas-operations/>.

<sup>23</sup> Lee Lane, *Institutional Choices for Regulating Oil and Gas Wells*, Hudson Institute, February 2013, <http://www.hudson.org/files/publications/Lane--OilGasWells--0213web.pdf>.

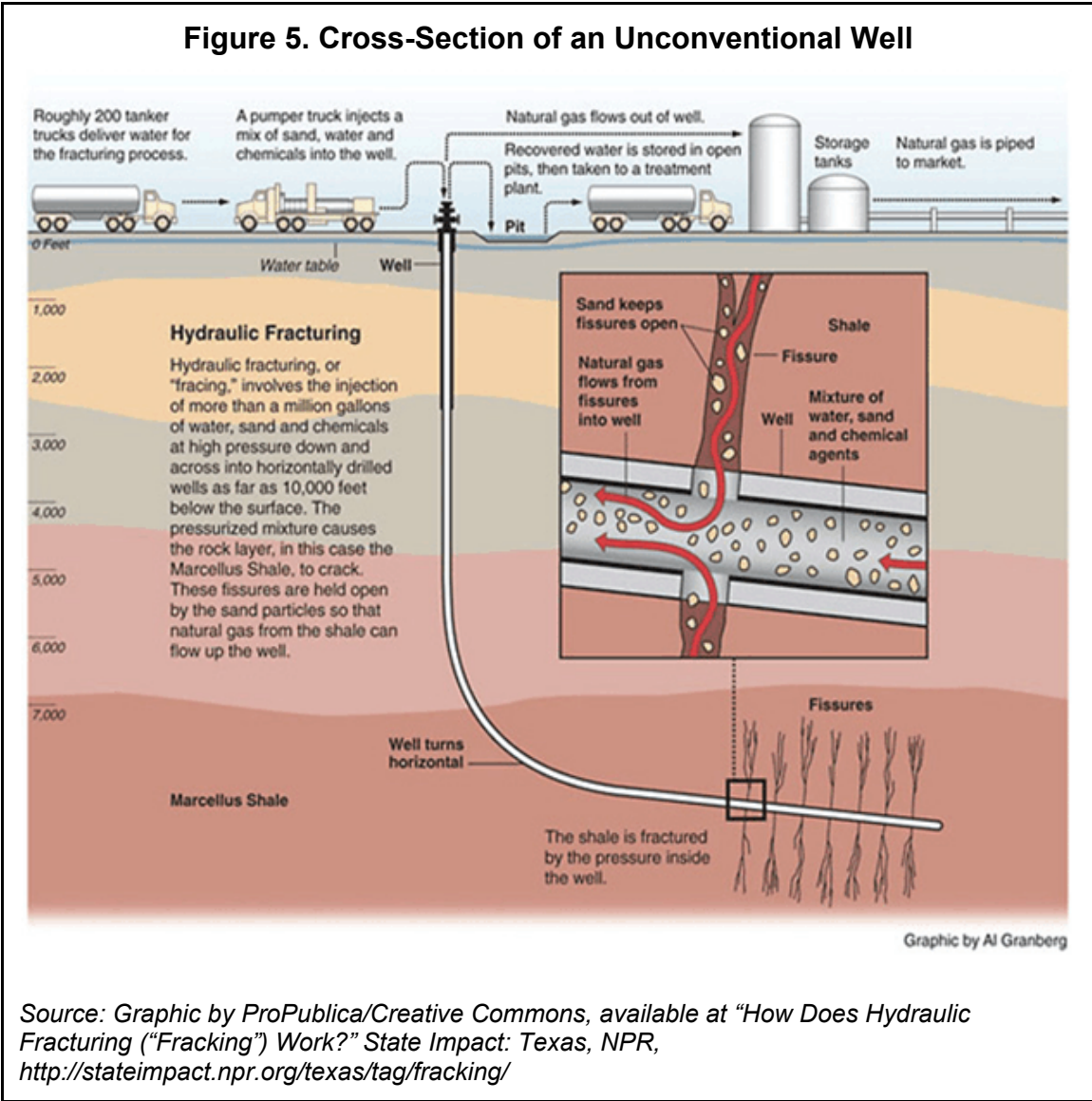
<sup>24</sup> Ben Wolfgang, "I Drank Fracking Fluid, Says Colorado Governor John Hickenlooper," *The Washington Times*, February 12, 2013, <http://www.washingtontimes.com/blog/inside-politics/2013/feb/12/colorado-gov-hickenlooper-i-drank-fracking-fluid/>.



<b>Figure 4. Fracking Fluid Chemicals and Their Daily Applications</b>			
<b>Additive Type</b>	<b>Main Compound(s)</b>	<b>Purpose</b>	<b>Common Use of Main Compound</b>
Diluted Acid (15%)	Hydrochloric acid or muriatic acid	Help dissolve minerals and initiate cracks in the rock	Swimming pool chemical and cleaner
Biocide	Glutaraldehyde	Eliminates bacteria in the water that produce corrosive byproducts	Disinfectant; sterilize medical and dental equipment
Breaker	Ammonium persulfate	Allows a delayed breakdown of the gel polymer chains	Bleaching agent in detergent and hair cosmetics manufacture of household plastics
Corrosion Inhibitor	N,n-dimethyl formamide	Prevents the corrosion of the pipe	Used in pharmaceuticals, acrylic fibers, plastics
Crosslinker	Borate salts	Maintains fluid viscosity as temperature increases	Laundry detergents, hand soaps, and cosmetics
Friction Reducer	Polyacrylamide	Minimizes friction between the fluid and the pipe	Water treatment, soil conditioner
	Mineral oil		Makeup remover, laxatives, and candy
Gel	Guar gum or hydroxyethyl cellulose	Thickens the water in order to suspend the sand	Cosmetics, toothpaste, sauces, baked goods, ice cream
Iron Control	Citric acid	Prevents precipitation of metal oxides	Food additive, flavoring in food and beverages; lemon juice ~7% citric acid
KCl	Potassium chloride	Creates a brine carrier fluid	Low sodium table salt substitute
Oxygen Scavenger	Ammonium bisulfite	Removes oxygen from the water to protect the pipe from corrosion	Cosmetics, food and beverage processing, water treatment
pH Adjusting Agent	Sodium or potassium carbonate	Maintains the effectiveness of other components, such as crosslinkers	Washing soda, detergents, soap, water softener, glass and ceramics
Proppant	Silica, quartz sand	Allows the fractures to remain open so the gas can escape	Drinking water filtration, play sand, concrete, brick mortar
Scale Inhibitor	Ethylene Glycol	Prevents scale deposits in the pipe	Automotive antifreeze, household cleansers, and de-icing agent
Surfactant	Isopropanol	Used to increase the viscosity of the fracture fluid	Glass cleaner, antiperspirant, and hair color
<p>Note: The specific compounds used in a given fracturing operation will vary depending on company preference, source water quality, and site-specific characteristics of the target formation. The compounds shown above are representative of the major compounds used in hydraulic fracturing of gas shales. <i>Source: United States Department of Energy, Modern Shale Gas Development in the United States: A Primer, April 2009, p. 63, <a href="http://fracfocus.org/node/93">http://fracfocus.org/node/93</a></i></p>			

**The Drilling Process**

An average unconventional gas well is drilled to a depth of 7,500 ft, the equivalent of five Willis Towers (formerly known as the Sears Tower) stacked on top of each other.<sup>25</sup> During the initial drilling phase, wells are drilled vertically to a depth below the deepest drinking water and irrigation aquifers. Steel surface casing is then inserted down the length of the drilled hole, and cement is pumped the length of the hole to create a barrier of cement and steel between the well, groundwater aquifers, and sensitive geologic formations.<sup>26</sup> Figure 5 describes the hydraulic fracturing process in greater detail.



<sup>25</sup> “Fracking Explained with Animation,” A2L Consulting, <http://www.youtube.com/watch?v=qm7e553S7fg>.

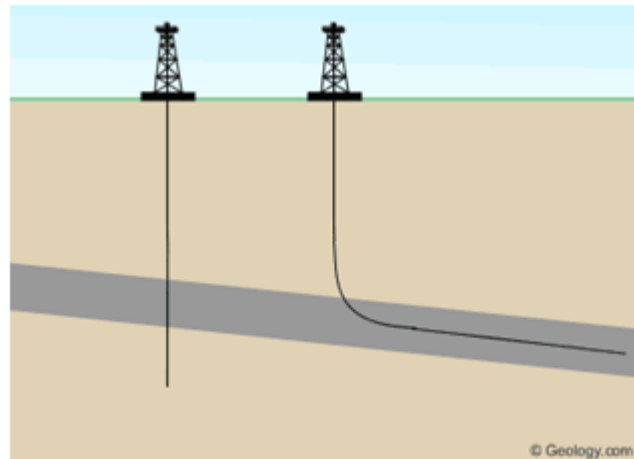
<sup>26</sup> Institute for Energy Research, “Hydraulic Fracturing—Is It Safe?” May 3, 2011, <http://www.instituteforenergyresearch.org/2011/05/03/hydraulic-fracturing-is-it-safe/>.

After the well has been cased with steel and cement, operators begin the horizontal drilling phase of the process by angling the well toward the rock layer containing the oil or gas, which is known as the target formation or the “payzone.” Horizontal drilling increases the surface area of the well located in the “pay zone,” increasing the amount of oil and gas that can be recovered with one well hole (see Figure 6). A single horizontal well can extend up to two miles away from the drilling pad and, depending on local factors such as geology and the availability of mineral leases, can produce 25 to 30 times more oil or gas on average than a conventional vertical well during the course of its lifetime.<sup>27</sup>

In addition to increasing exposure of the target formation to the well, horizontal drilling makes it possible to drill multiple wells in different directions from the same drilling pad. In 2010 the University of Texas at Arlington drilled 22 wells on a single platform to recover the natural gas from about 1,100 acres of area beneath the campus (see Figure 7).<sup>28</sup>

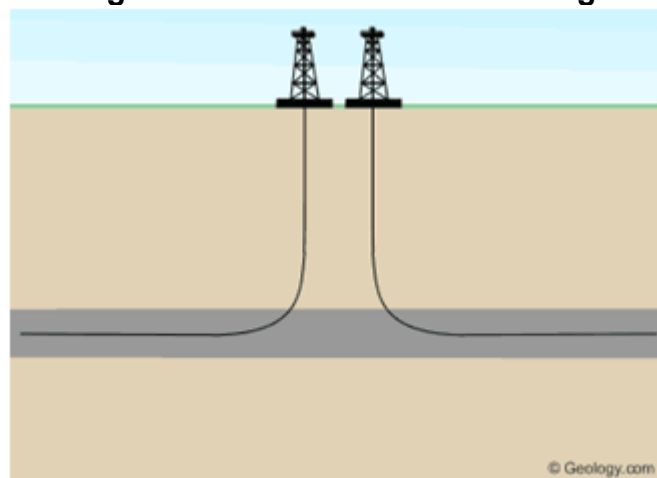
A recent study by Cornell University found 83 percent of the wells drilled in the Marcellus Shale during 2011 were on multi-well pads. The study also

**Figure 6. Vertical Drilling Compared to Horizontal Drilling**



The dark gray area represents the rock formation containing oil or gas reserves. By using horizontal drilling techniques, producers are able to access more of the target formation and drill fewer holes. *Source: Geology.com*

**Figure 7. Multi-directional Drilling**



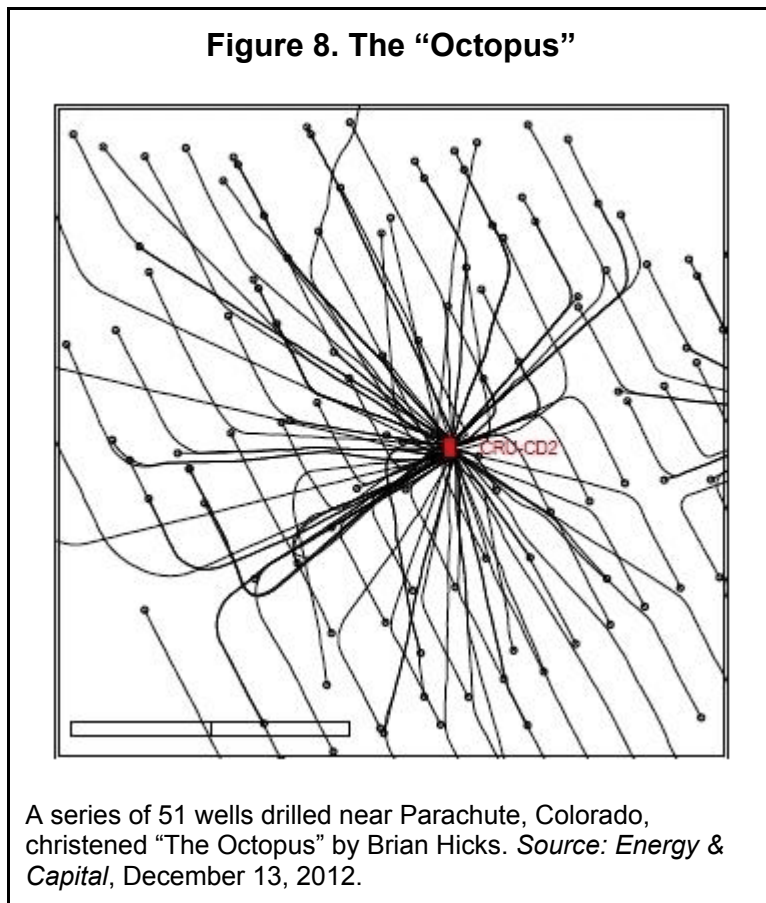
Horizontal and directional drilling allow for multiple wells to be drilled in different directions, increasing access to oil and gas resources while decreasing surface disturbance. *Source: Geology.com*

<sup>27</sup> Joe Carroll and Edward Klump, “Shale Drillers Squeeze Costs as Era of Exploration Ends: Energy,” Bloomberg, June 14, 2013, <http://www.bloomberg.com/news/2013-06-13/shale-drillers-squeeze-costs-as-era-of-exploration-ends-energy.html>.

<sup>28</sup> Hobart King, “Directional Drilling in Oil and Gas Wells,” <http://geology.com/articles/horizontal-drilling/>.

found drilling multiple wells on a single pad works in the field, and not just on a university campus, which could further reduce the surface disturbance and associated industrial infrastructure of up to 12 wells, or possibly more, in a single area.<sup>29</sup>

Figure 8 shows the layout of a network of wells in Parachute, Colorado. In total, 51 wells were drilled from one well pad, enabling gas producers to access 640 acres of gas reserves from a single 4.6 acre pad.<sup>30</sup> A statement by Devon Energy indicates well pads generally take up the



same amount of space regardless of the number of wells located on a site, meaning it would have required 51 individual conventional wells disturbing the surface of 243 acres to achieve the same amount of energy production currently achieved by disturbing the surface of only 4.6 acres.<sup>31</sup>

Multi-well drill pads increase the profitability of drilling operations by creating economies of scale and minimizing the total number of wastewater ponds, treatment facilities, access roads, and gathering lines required to produce a particular amount of energy, while greatly reducing the amount of land requiring reclamation after the drilling is over.

The Interstate Oil and Gas Compact Commission, a multistate government agency

representing oil- and gas-producing states in Congress, estimates hydraulic fracturing has been used in more than one million wells since 1947. Currently, hydraulic fracturing is used to stimulate production in 90 percent of domestic oil and gas wells (conventional and

<sup>29</sup> Jim Ladee and Jeffery Jaquet, “The Implications of Multi-Well Pads in the Marcellus Shale,” Community and Regional Development Institute, Cornell University, *Research and Policy Brief Series*, No. 43, September 2011, <http://cardi.cornell.edu/cals/devsoc/outreach/cardipublications/loader.cfm?csModule=security/getfile&PageID=1016988>.

<sup>30</sup> Brian Hicks, “Multi-Well Pad Will Sink OPEC,” *Energy & Capital*, December 13, 2012, <http://www.energyandcapital.com/articles/multi-well-pad/2892>.

<sup>31</sup> Devon Energy, “Multi-Well Pads Becoming the Norm,” <http://www.dvn.com/CorpResp/initiatives/Pages/Multi-wellPads.aspx#terms?disclaimer=yes>.

unconventional), though smart drilling methods utilize fracking to a much greater degree than conventional oil and gas development.<sup>32</sup>

The United States is an energy-hungry nation, and this demand must be met through increased domestic production or reliance on foreign imports. Smart drilling has enabled the United States to increase domestic oil and gas production to meet demand while reducing the surface disturbance and creating thousands of jobs across the nation.

## Frack to the Future: The Economic Impacts of Hydraulic Fracturing

With the increased application of smart drilling, the United States has increased domestic natural gas production by 34 percent since 2005, becoming the world's leading producer.<sup>33</sup> Net imports of natural gas have fallen nearly 50 percent since 2007, and as a result imports account for only 8 percent of total U.S. natural gas consumption.

Reduced reliance on imports has improved the U.S. trade balance and stimulated the economy as domestic supply has grown to meet demand.

With the increased application of smart drilling, the United States has increased domestic production of natural gas by 34 percent since 2005, becoming the world's leading producer.

Since smart drilling was found to be economically viable in 2003, unconventional energy production has resulted in the creation of thousands of new jobs across the country. In 2012 the unconventional oil and gas industry supported 360,000 direct jobs and 537,000 indirect supply-industry jobs (equipment manufacturers, frac sand mine operators, steel workers, truckers, etc.), and an estimated 850,000 induced jobs were supported by oil and gas workers spending their paychecks in the general economy at grocery stores, dentist offices, movie theaters, auto-dealerships, etc.<sup>34</sup>

Employment is projected to increase further by 2020, when the unconventional oil and gas industries are estimated to support a total of 600,000 direct jobs, 900,000 indirect jobs, and 1.5 million induced jobs.

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<sup>32</sup> Railroad Commission of Texas, *Testimony Submitted to the House Committee on Energy and Commerce by Victor Carillo, chairman, Texas Railroad Commission, Representing the Interstate Oil and Gas Compact Commission*, February 10, 2005.

<sup>33</sup> U.S. Energy Information Administration, *supra* note 8.

<sup>34</sup> IHS Inc., *America's New Energy Future: The Unconventional Oil and Gas Revolution and the U.S. Economy*, October 2012, [http://www.energyxxi.org/sites/default/files/pdf/americas\\_new\\_energy\\_future-unconventional\\_oil\\_and\\_gas.pdf](http://www.energyxxi.org/sites/default/files/pdf/americas_new_energy_future-unconventional_oil_and_gas.pdf).

Although job creation from a specific industry, especially induced jobs, can be a debatable metric of economic impact, the likelihood is that the new jobs created by unconventional oil production are occurring because domestic oil production is displacing purchases of imports rather than domestically produced substitutes, and it is therefore likely the benefits of increased production are felt by the U.S. economy.

Average wages for drilling and extraction jobs vary from approximately \$20/hour for skilled and semiskilled workers (some having only a high school diploma) to \$35/hour for professional workers, exceeding the national median by 11 percent and 15 percent, respectively.<sup>35</sup>

Nowhere is the economic potential of shale oil and gas production more evident than in towns like Williston, North Dakota. Williams County, which includes the city of Williston, has experienced a 316 percent growth in jobs, from 8,671 in 2000 to 36,107 in the third quarter of 2012.

Since oil production in the Bakken Formation began, North Dakota has climbed from eighth-largest oil-producing state in the nation in 2007 to second place today, eclipsing Alaska.

Since oil production in the Bakken Formation began, North Dakota has climbed from eighth-largest oil-producing state in the nation in 2007 to second place today, eclipsing Alaska (see Figure 9).<sup>36</sup> The growth in oil production in North Dakota has supported the creation of 70,000 new jobs state-wide in the past five years. These jobs are a major reason why the North Dakota

unemployment rate has remained the lowest in the nation, steadily holding near 3.2 percent. North Dakota also has experienced the highest population growth rate in the nation, increasing 2.17 percent in 2012 and 9 percent since 2000.<sup>37</sup>

Additionally, personal income growth in North Dakota has been the highest in the nation for five of the past six years.<sup>38</sup> Average weekly wages in the 12 Bakken counties have increased by 49 percent from 2010 to 2012 as employers have been forced to raise wages to compete with oil production companies for labor. For example, wages at the local McDonald's start at \$25,000 annually.<sup>39</sup>

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<sup>35</sup> *Ibid.*

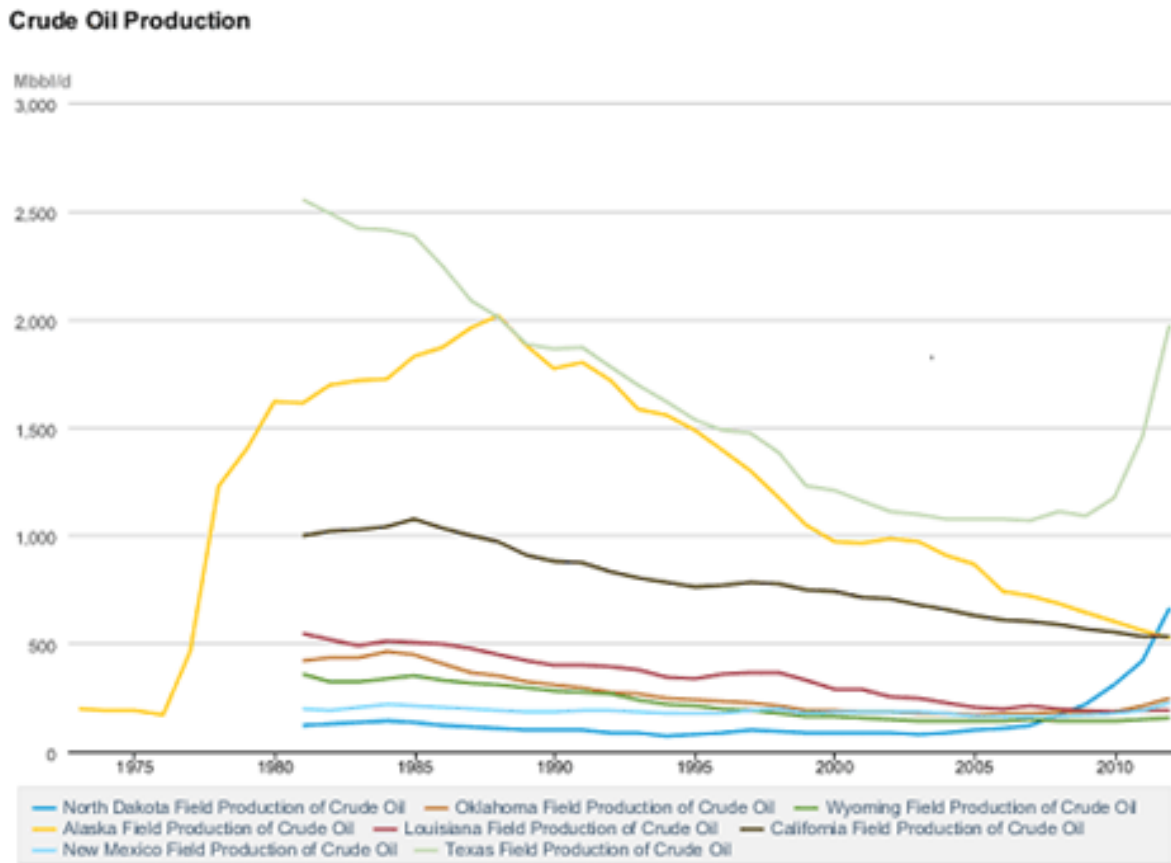
<sup>36</sup> U.S. Energy Information Administration, U.S. Crude Oil Production in First Quarter 2012 Highest in 14 Years, June 8, 2012, <http://www.eia.gov/todayinenergy/detail.cfm?id=6610>.

<sup>37</sup> Christopher Bjorke, "ND Up 100k Jobs Since 2000," *The Dickinson Press*, April 10, 2013, <http://www.thedickinsonpress.com/event/article/id/67303/>.

<sup>38</sup> Morgan Brennan, "North Dakota Leads List of America's Fastest Growing States," *Forbes.com*, December 20, 2012, <http://www.forbes.com/sites/morganbrennan/2012/12/20/north-dakota-leads-list-of-americas-fastest-growing-states/>.

<sup>39</sup> Kris Hudson, "Oil Boom By-Product: Unaffordable Housing," *Wall Street Journal*, April 4, 2013, <http://online.wsj.com/article/SB10001424127887324883604578396491794558304.html>.

**Figure 9. Crude Oil Production in the U.S.**



During much of the previous decades, North Dakota was the eighth largest oil producing state. Since the development of the Bakken oil field, it has become the second-largest oil-producing state in the nation. *Source: U.S. Energy Information Administration*

The growth in smart oil and gas production is fueled primarily by the exploration and production industries, which invested \$87 billion in 2012. In addition, the majority of the tools, technology, and knowledge needed to perform hydraulic fracturing are homegrown, resulting in an overwhelming majority of every dollar spent entering the domestic supply-chain and supporting domestic jobs, making boomtowns like Williston possible. Annual capital investments are projected to grow throughout the decade, from \$87 billion currently to \$172.5 billion by the end of the decade.<sup>40</sup>

This investment has spurred the rapid expansion in the nation's shale plays. Figure 10 is a map labeling the key oil and gas deposits in the lower 48 states. U.S. shale reserves are the

<sup>40</sup> IHS Inc., *supra* note 34.

second-largest in the world,<sup>41</sup> constituting approximately 2,384 trillion cubic feet of natural gas, enough to meet current domestic demand for 98 years. Additionally, it is important to note that reserve estimates are not a static number; they fluctuate based on the ability of oil and gas producers to extract the resource from the ground economically, meaning reserve estimates could grow with increasingly efficient technology or rising prices.

Figure 10. Shale Plays of the Lower 48 States



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

“Shale play” is the term used in the oil and gas industry for a geological formation that has been targeted for exploration. Source: U.S. Energy Information Administration; Eagle Ford Shale Blog, “What is a Shale Play,” <http://eaglefordshaleblog.com/2010/03/03/what-is-a-shale-gas-play/>.

The shale boom places the United States in the enviable position of having the largest demand for natural gas and among the lowest global prices. Although natural gas prices have been historically volatile, supply-stability in the coming years is projected to reduce price fluctuations. Once considered supply-constrained, smart drilling and the resulting increases in gas production have made the U.S. natural gas market demand- constrained. Prices have plummeted from the

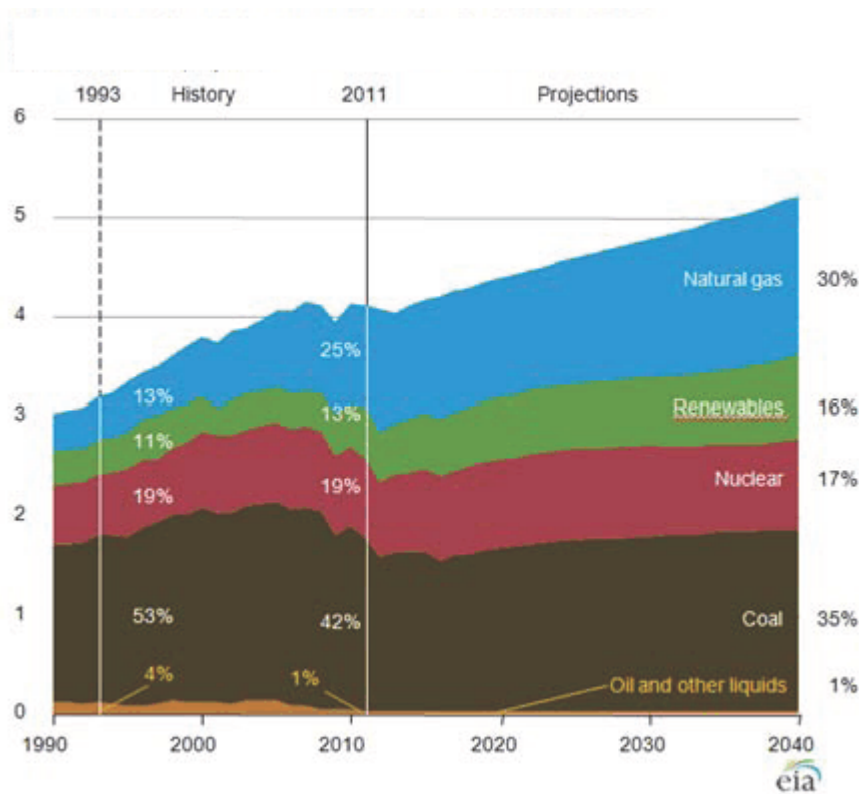
<sup>41</sup> Shale reserve figures were not available for Russia, a major player in the oil and gas industry.



highs of \$16/MMbtu briefly experienced in 2005 to approximately \$4.15/MMbtu today. Low natural gas prices have made it a more cost-effective option for electricity generation than coal in many situations; as a result, electricity prices have fallen.

Natural gas accounted for 25 percent of the fuel burned for U.S. electricity generation in 2011 (see Figure 11). According to EIA projections, much of the growth in electricity demand in the coming decades will be met by natural gas. These projections have been substantiated by the fact that in 2012, the U.S. produced 30 percent of its electricity by burning natural gas, a level it was not projected to achieve until 2040.<sup>42</sup> The manufacturing sector also will use more natural gas for energy and as a feedstock for plastics and chemicals.

**Figure 11. Electricity Generation by Fuel 1990–2040**  
(trillion kilowatt hours per year)

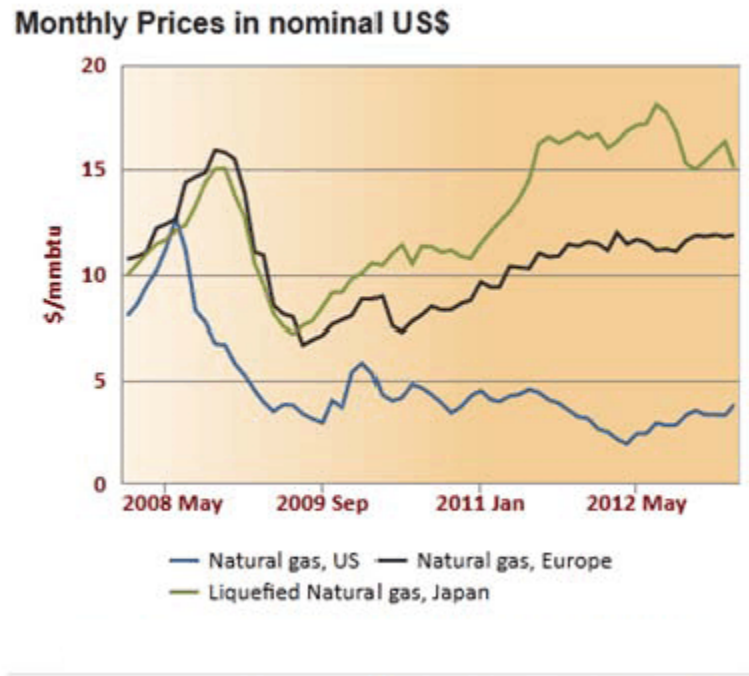


Growing demand for electricity will be met largely by using more natural gas for electricity generation as its share of the electricity generation market is predicted to rise to 30 percent in 2040. *Source: Energy Information Administration*

<sup>42</sup> U.S. Energy Information Association, AEO2013 Early Release Overview, DOE/EIA-0383ER (2013), December 5, 2012, [http://www.eia.gov/forecasts/aeo/er/early\\_elecgen.cfm](http://www.eia.gov/forecasts/aeo/er/early_elecgen.cfm).

Low natural gas and electricity prices have given the United States a competitive advantage in energy- and feedstock-intensive industries such as manufacturing, fertilizer production, steel and aluminum processing, petrochemical production, and plastic production, relative to their European and Asian counterparts (see Figure 12).<sup>43</sup> As a result, foreign investors such as Voestalpine, an Austrian steel firm, and Japanese oil refiner Idemitsu Kosan and trading house Mitsui & Co. have opened operations in the United States.<sup>44</sup>

**Figure 12. Comparison of Global Natural Gas Prices**



The United States currently enjoys a competitive advantage over Europe and Japan as natural gas is three to four times less expensive in America. *Source: World Bank Commodity Price Data (Pink Sheet), April 2013.*

Low natural gas prices are one reason the U.S. manufacturing sector has seen much faster growth of output compared to other advanced nations.<sup>45</sup> Since 2010, the U.S. manufacturing industry has created nearly half a million jobs and the National Association of Manufacturers estimates the

<sup>43</sup> "Shale Boom Sparks U.S. Industrial Revival," CNBC, March 26, 2013, <http://www.cnbc.com/id/100592605>.

<sup>44</sup> *Ibid.*

<sup>45</sup> Marilyn Geewax, "Cheap Natural Gas Pumping New Life Into U.S. Factories," National Public Radio, March 28, 2013, <http://www.npr.org/2013/03/28/175483517/cheap-natural-gas-pumping-new-life-into-u-s-factories>.

shale boom will add one million manufacturing jobs to the economy by 2025. Additionally, it has been reported that Boeing, General Electric, and Apple will bring back some of the jobs they moved overseas to cut costs, aided partially by lower natural gas prices.<sup>46</sup>

Unconventional oil and gas production also are generating revenue for state, local, and federal governments. In 2012, total tax revenues from unconventional oil and gas production were approximately \$62 billion, with 2020 revenues projected to grow to more than \$111 billion. These taxes include corporate income taxes from the production and supply-chain of industries and personal income taxes from direct, indirect, and induced employees.<sup>47</sup>

States such as California and Illinois, two states with perennial budget deficits, have noticed this revenue and are looking to the oil and gas industries as a possible way of reducing their budget deficits. A recent study by the University of Southern California estimates hydraulic fracturing in California would yield 2.8 million jobs and \$24.6 billion in tax revenue by 2020.<sup>48</sup> The State of Illinois has adopted regulations approved by industry and environmental groups to facilitate the growth of unconventional energy production, due in no small part to the desire for additional income in the state treasury.<sup>49</sup>

The Yale Graduates in Energy Study Group found the benefits of hydraulic fracturing exceed the costs by a ratio of 400–1.

Hydraulic fracturing has benefited both the private and the public sector, but these benefits are not without costs. A study by the Yale Graduates in Energy Study Group provides insights into the cost-benefit analysis of hydraulic fracturing.

The study calculated the benefit derived from hydraulic fracturing to be \$100 billion annually in the form of lower natural gas prices for consumers. To calculate the cost of hydraulic fracturing, the authors assumed 100 spills for every 10,000 new wells drilled and a cost of approximately \$2.5 million if 5,000 gallons of wastewater were spilled and it was necessary to remove 5,000 cubic yards of contaminated soil. If groundwater wells were contaminated, the cost of providing water to residents would be approximately \$5,000 per well. In all, the costs associated with 100 accidents every year would be approximately \$250 million, making the cost-benefit ratio 400–1.<sup>50</sup>

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<sup>46</sup> CNBC, *supra* note 43.

<sup>47</sup> IHS Inc., *supra* note 34.

<sup>48</sup> Alison Vekshin, "California Fracking Fight Has \$25 Billion Taxes at Stake," Bloomberg, March 13, 2013, <http://www.bloomberg.com/news/2013-03-17/california-fracking-fight-has-25-billion-taxes-at-stake.html>.

<sup>49</sup> Patrick Yeagle, "What to Expect with Fracking," *Illinois Times*, June 27, 2013, <http://www.illinoistimes.com/Springfield/article-12566-what-to-expect-with-fracking.html>.

<sup>50</sup> Christopher Helman, "The Arithmetic of Shale Gas," Forbes.com, June 22, 2012, <http://www.forbes.com/sites/christopherhelman/2012/06/22/the-arithmetic-of-shale-gas/>.

These projected costs, while vastly outweighed by the benefits, are not insignificant. While policymakers decide on their next course of action, it is important to understand the impacts oil and gas production could have on the environment. Part Two focuses on the environmental impact using studies from peer-reviewed publications in an attempt to provide the most accurate and up-to-date information possible.

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## PART 2

### Environmental Impact

#### Environmental Concerns

Environmental damage is a legitimate concern, yet it must be viewed in light of cost-benefit analysis and not absolute terms.

Benefits from hydraulic fracturing are realized in economic and social terms, whereas the costs are realized in the form of potential environmental impacts. The prospect of large-scale hydraulic fracturing has provoked fears of contaminated water and a new era of manmade earthquakes. These

fears led New Jersey,<sup>51</sup> New York, North Carolina, and Vermont to place moratoria on hydraulic fracturing.

Environmental damage is a legitimate concern, yet it must be viewed realistically and in light of cost-benefit analysis and not absolute terms. Among the key areas of concern cited by opponents of unconventional oil and gas production are water consumption, groundwater contamination, wastewater disposal, earthquakes, and greenhouse gas emissions.

This study addresses each of these impacts and determines that reasonable measures short of moratoria and bans can be taken to mitigate environmental damage while allowing for the responsible extraction of oil and gas resources.

#### ***Water Consumption***

Hydraulic fracturing is often portrayed as a water-intensive industry due to the large volumes of water injected into wells to break up shale formations (approximately two million to four million gallons per well). However, when compared to other uses, such as conventional oil and gas

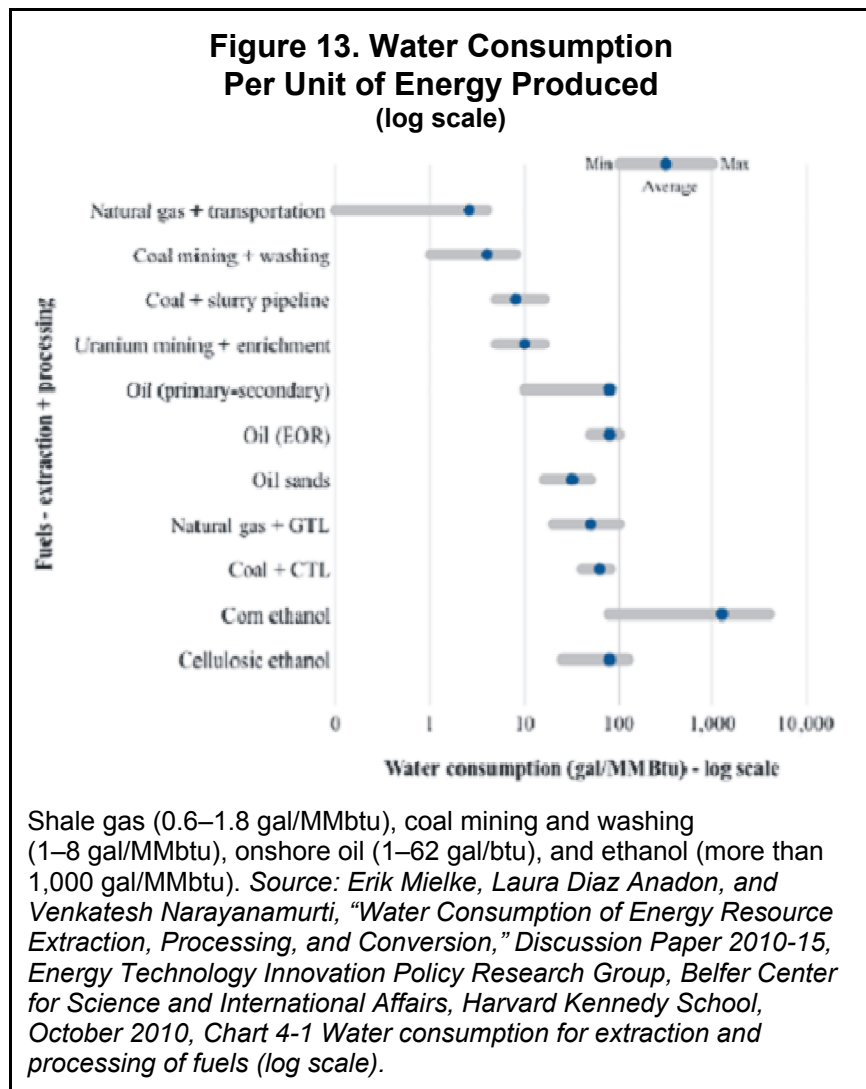
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<sup>51</sup> New Jersey enacted a one-year moratorium that has since expired.

drilling, coal mining, biofuel production, household, and agricultural use, the amount of water consumed for unconventional oil and gas production is relatively small.

Water consumption is determined by calculating the amount of water that is evaporated, contaminated, or stored. In 2011, shale gas production consumed approximately 135 billion gallons of water nationwide. Using the most recent freshwater consumption data from the United States Geological Survey (USGS), the United States consumed 43,800 billion gallons of water in 2005. Using the 2005 water consumption data as a baseline for current use, hydraulic fracturing accounted for just .3 percent of the total water consumed, compared to the .5 percent used to irrigate golf courses annually.<sup>52</sup>

Additionally, shale gas production consumes less water per unit of energy generated than onshore oil production, ethanol production, and washing coal after it has been mined, as demonstrated in Figure 13.<sup>53</sup>

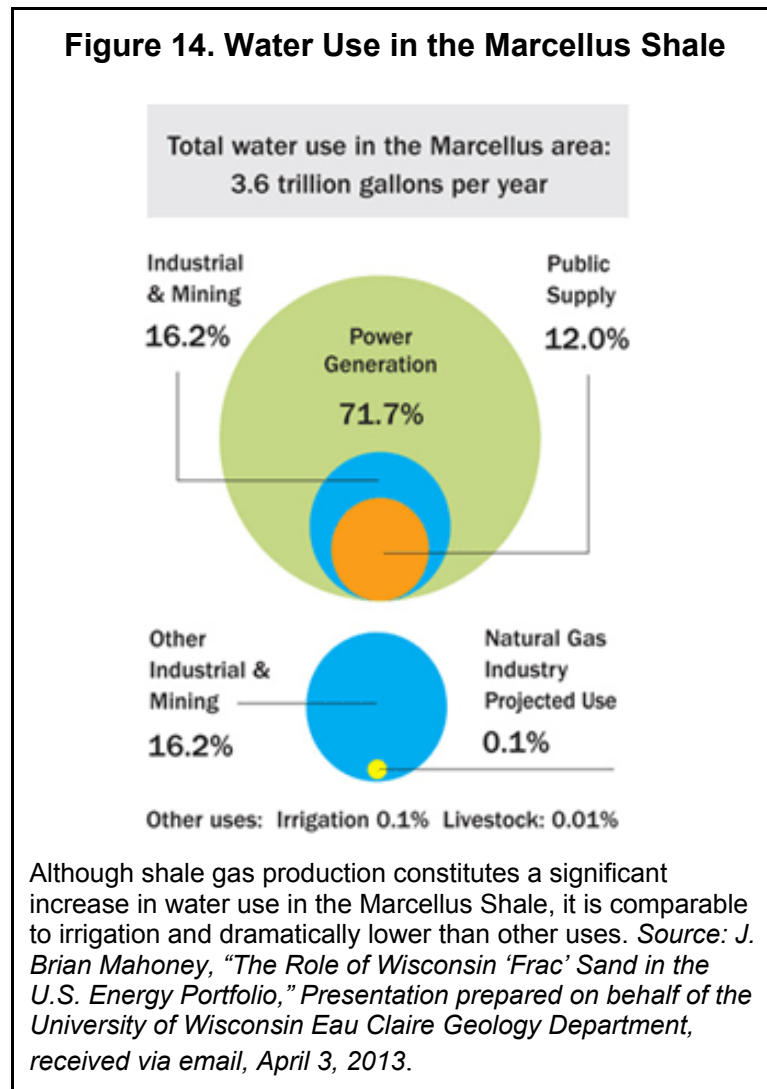


Although the scale of the hydraulic fracturing conducted in the Marcellus Shale represents an increase in total water consumption, it rivals the water levels used for irrigation and is dwarfed

<sup>52</sup> Jesse Jenkins, “Energy Facts: How Much Water Does Fracking For Shale Gas Consume?” The Energy Collective, April 6, 2013, <http://theenergycollective.com/jessejenkins/205481/friday-energy-facts-how-much-water-does-fracking-shale-gas-consume>.

<sup>53</sup> Erik Mielke, Laura Diaz Anadon, and Venkatesh Narayanamurti, “Water Consumption of Energy Resource Extraction, Processing, and Conversion,” *Discussion Paper 2010-15*, Energy Technology Innovation Policy Research Group, Belfer Center for Science and International Affairs, Harvard Kennedy School, October 2010, <http://belfercenter.ksg.harvard.edu/files/ETIP-DP-2010-15-final-4.pdf>.

by other uses such as the public water supply, power generation, and other industrial and mining consumption, as demonstrated in Figure 14.<sup>54</sup>



Additionally, although Texas has the highest unconventional gas and oil production in the nation, hydraulic fracturing accounted for just 1 percent of freshwater withdrawals there, with the water consumed at the Barnett Shale, the largest shale play in the state, equal to about 9 percent of the annual water consumption of the city of Dallas.<sup>55</sup>

Although hydraulic fracturing utilizes considerable quantities of water, shale gas development has been mischaracterized as an especially water-intensive industry. In arid regions where water supplies are scarce, local authorities are best equipped to make decisions regarding appropriate water use, but when compared to other water uses such as thermal energy production, agriculture, and public consumption, the impact of hydraulic fracturing on fresh water supplies is relatively small.

### Groundwater Contamination

Public opposition to hydraulic fracturing often stems from fear that methane (the main hydrocarbon in natural gas) and fracking fluid chemicals will contaminate groundwater aquifers and compromise drinking water supplies.

<sup>54</sup> J. Brian Mahoney, "The Role of Wisconsin 'Frac' Sand in the U.S. Energy Portfolio," Presentation prepared on behalf of the University of Wisconsin Eau Claire Geology Department, received via email, April 3, 2013.

<sup>55</sup> Jean Philippe Nicot and Bridget Scanlon, "Water Use in Shale Gas Production in Texas, US," *Environmental Science and Technology* 46 (2012), pp. 3580-6, [http://www.beg.utexas.edu/staffinfo/Scanlon\\_pdf/Nicot+Scanlon\\_ES&T\\_12\\_Water%20Use%20Fracking.pdf](http://www.beg.utexas.edu/staffinfo/Scanlon_pdf/Nicot+Scanlon_ES&T_12_Water%20Use%20Fracking.pdf).

Perhaps the most powerful image associated with hydraulic fracturing is the scene from the movie *Gasland* where Mike Markham ignites the water running from the faucet of his Colorado home. Later analysis by the Colorado Oil and Gas Conservation Commission (COGCC) determined the methane found in Markham's well was biogenic in origin, naturally occurring, and found in the coal formations present within the aquifer supplying his drinking water, not thermogenic methane, a key component of natural gas. The well did not test positive for chemicals used in the fracking process, providing further evidence that oil and gas production was not the cause of contamination.<sup>56</sup>

A study conducted by Duke University analyzing 68 water wells in the Marcellus Shale found 85 percent of wells contained methane regardless of gas industry operations. Researchers concluded the methane in these wells was thermogenic in origin, but they were unable to establish a direct, causal link between hydraulic fracturing and well water contamination, due to a lack of historic data for baseline analysis. Here too, no evidence of fracking fluid was found in water samples.<sup>57</sup>

Instances of groundwater impairment due to activities associated with natural gas and oil production, such as surface spills and leaks from improperly cased wells, have been known to occur in conventional wells in addition to unconventional wells. However, there has been no conclusive evidence

There has been no conclusive evidence provided to support the claim that hydraulic fracturing has caused groundwater contamination.

provided to support the claim that hydraulic fracturing has caused groundwater contamination.<sup>58</sup> This conclusion was reiterated by David Neslin, director of the COGCC, in a letter providing written answers to follow-up questions by the Senate Committee on Environment and Public Works. In that letter, Neslin testified the COGCC had found no verified incidences of hydraulic fracturing contaminating groundwater.<sup>59</sup>

Current regulations set minimum standards regarding well bore strength, well casing procedures, fluid and gas migration prevention, and other possible sources of contamination, designed to protect the environment while facilitating the responsible extraction of natural resources. Businesses have strong motives to avoid oil- and gas-related activities that compromise drinking

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<sup>56</sup> Department of Natural Resources, Colorado Oil and Gas Conservation Commission, *Gasland Document*, n.d., <http://cogcc.state.co.us/library/GASLAND%20DOC.pdf>.

<sup>57</sup> Jeffrey C. King, Jamie Lavergne Bryan, and Meredith Clark, "Factual Causation: The Missing Link in Hydraulic Fracture—Groundwater Contamination Litigation," *Duke Environmental Law & Policy Forum* 22 (Spring 2012), pp. 341–60, <http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=1234&context=delpf>.

<sup>58</sup> *Ibid.*

<sup>59</sup> David Neslin, *Written Answers to Follow Up Questions from the Senate Committee on the Environment and Public Works*, Colorado Oil and Gas Conservation Commission, submitted May 17, 2011, <http://www.savecoloradofromfracking.org/whatgoeswrong/Resources/Neslin%20Testimony%20EnviroPublicWorksQA.pdf>.

water, such as surface spills, faulty casing, machinery malfunction, and operator error. Such accidents increase expenses, interrupt production, create legal liabilities, may violate government regulations, and may require restitution for those affected.

To aid investigators in examining future claims of contamination, baseline data from areas near proposed wells should be obtained prior to drilling, thus providing the information necessary to determine the source of groundwater contamination and hold accountable those whose actions led to contamination.

With no confirmed cases of water well or groundwater contamination directly linked to the process of hydraulic fracturing, calls for moratoria are not supported by science. States should instead seek to create a regulatory framework to mitigate environmental damage, rather than ban hydraulic fracturing.

## **Wastewater**

Most of the water used to hydraulically fracture unconventional wells remains underground after the fracking process is complete, but approximately 15 to 20 percent is returned to the surface through a steel-cased well bore and temporarily stored in steel tanks or lined pits. This wastewater is referred to as flowback water.<sup>60</sup>

Most of the water used to hydraulically fracture unconventional wells remains underground after the fracking process is complete.

In the February 2013 issue of *Water Resource Research*, Brian Lutz and Aurana Lewis state shale gas production in the Marcellus Shale – the largest shale gas play in the country, producing 10 percent of U.S. natural gas – produces approximately 65 percent less wastewater per unit of natural gas recovered

than conventional gas drilling.<sup>61</sup> The study quantified natural gas and wastewater production at 2,189 shale gas wells in the Marcellus Shale. Lutz and Lewis determined that although shale gas wells produce ten times more wastewater on average than conventional wells, they produce approximately *thirty times* as much natural gas as conventional wells.

Although hydraulically fractured wells in the Marcellus Shale were found to produce 65 percent less wastewater per unit of gas recovered than conventional wells, the rapid expansion of natural gas production in Pennsylvania has caused related wastewater to increase by 570 percent since

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<sup>60</sup> Jeff Fort, “Exploring the Disposal of Fracking Waste Water—UIC Class II Wells in Ohio,” *Oil and Gas Law Report*, April 13, 2013, <http://www.oilandgaslawreport.com/2013/04/13/exploring-the-disposal-of-fracking-waste-water-uic-class-ii-wells-in-ohio/>.

<sup>61</sup> Brian D. Lutz, Aurana N. Lewis, and Martin W. Doyle, “Generation, Transport, and Disposal of Wastewater Associated with Marcellus Shale Gas Development,” *Water Resources Research* 49, No. 2 (February 2013), pp. 647–56.



2004, and it must be disposed of properly.<sup>62</sup> Depending on well location, disposal comes in two primary forms: recycling and injection wells.

Injection wells, also known as disposal wells, are deep wells that pump waste materials or carbon dioxide (CO<sub>2</sub>) into isolated formations far below the Earth's surface and are designed to provide multiple layers of protective casing and cement.<sup>63</sup> Injection wells are the most common form of wastewater disposal in much of the country because they provide a cost-effective means of disposing of large quantities of water in an environmentally responsible way.

The United States Environmental Protection Agency (EPA) regulates the use of injection wells under the Safe Drinking Water Act (SDWA) and considers them a safe and effective way to protect water and soil resources. Approximately 30,000 Class II injection wells are used to dispose of oil and gas waste. Although economical, this method requires transportation of waste fluid to disposal sites, and it has been known to contribute to induced seismic activity, which will be discussed in a later section.

Recycling the wastewater generated at hydraulic fracturing sites has become a popular option.

As concerns over the use of injection wells and the availability of fresh water have become more prominent, recycling the wastewater generated at hydraulic fracturing sites has become a more popular option. Gas producers in the Marcellus Shale have formed the Center for Sustainable Shale Development, a consortium dedicated to establishing best practices, which include recycling 90 percent of their wastewater.<sup>64,65</sup> In Texas, the Railroad Commission recently adopted rules removing regulatory hurdles for recycling flowback water.

As more emphasis is placed on water conservation, recycling flowback water and experimental waterless fracturing techniques will likely become more prominent in oil and gas production.

## **Earthquakes**

Some environmental groups claim greater use of hydraulic fracturing will usher in a new era of manmade earthquakes. Although studies have found the process of hydraulic fracturing can cause small earthquakes, there is a greater risk of induced seismicity associated with the use of injection wells for the disposal of wastewater. The first earthquake caused by an injection well in

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<sup>62</sup> *Ibid.*

<sup>63</sup> U.S. Environmental Protection Agency, "Basic Information about Underground Injection Wells," May 2012, <http://water.epa.gov/type/groundwater/uic/basicinformation.cfm>.

<sup>64</sup> Susan Brantley and Anna Meyendorff, "The Facts on Fracking," *New York Times*, March 13, 2013, [http://www.nytimes.com/2013/03/14/opinion/global/the-facts-on-fracking.html?pagewanted=all&\\_r=2&](http://www.nytimes.com/2013/03/14/opinion/global/the-facts-on-fracking.html?pagewanted=all&_r=2&).

<sup>65</sup> Center for Sustainable Shale Development, *Performance Standards*, March 2013, <http://037186e.netsolhost.com/site/wp-content/uploads/2013/03/CSSD-Performance-Standards-3-27-GPX.pdf>.

the United States occurred in 1965 at a military complex in Colorado, where a disposal well was used to dispose of military waste, causing what became known as the “Denver Earthquakes.”<sup>66</sup>

Of nearly 200 instances of manmade earthquakes studied, hydraulic fracturing was found to have been responsible for three earthquakes large enough to be felt on the surface.

The risk of earthquakes directly related to hydraulic fracturing is small compared to other human activities, which can cause comparatively large tremors. A study conducted by Dr. Richard Davies, a professor of earth sciences at Durham University, compiled 198 published examples of induced seismic activity (manmade earthquakes) from

around the world registering at a magnitude greater than or equal to 1.0 since 1929. The study found hydraulic fracturing was responsible for only three earthquakes large enough to be felt on the surface—one in Canada, one in the United States, and one in the United Kingdom. Of these three earthquakes, the largest occurred in 2011 in the Horn River Basin of Canada, registering at M3.8, a magnitude on the lower end of earthquakes that can be felt by people.<sup>67</sup>

Other human activities can trigger much larger earthquakes. For example, building dams and filling reservoirs have caused earthquakes ranging in magnitude from M2.0 to M7.9, mining can cause earthquakes in the M1.6 to M5.6 range, using injection wells for carbon capture and sequestration and disposing of wastewater can trigger M2.0 to M5.3 quakes, and using geothermal energy wells has caused earthquakes in the M 1.0 to M4.6 range.<sup>68</sup>

Earthquakes must generally be in the M5.5 to M6 range before slight damage occurs to buildings.<sup>69</sup> Furthermore, it is important to note that an M3.5 earthquake is not half as strong as an M7, because the moment magnitude scale is logarithmic – each whole number on the scale is ten times as large as the preceding number. Therefore, an M6 is *one hundred times more intense* than an M4. For earthquakes to be felt on the surface, they must be near M4.0. This reasoning prompted Davies to give the following statement:

We have concluded that hydraulic fracturing is not a significant mechanism for inducing felt earthquakes. It is extremely unlikely that any of us will ever be able to feel an earthquake caused by fracking.<sup>70</sup>

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<sup>66</sup> Richard Davies, Gillian Foulger, Annette Bindley, and Peter Styles, “Induced Seismicity and Hydraulic Fracturing for the Recovery of Hydrocarbons,” *Marine and Petroleum Geology*, 2013, [https://pangea.stanford.edu/researchgroups/scits/sites/default/files/10679\\_0.pdf](https://pangea.stanford.edu/researchgroups/scits/sites/default/files/10679_0.pdf).

<sup>67</sup> *Ibid.*

<sup>68</sup> *Ibid.*

<sup>69</sup> Michigan Tech. University, UPSeis, Earthquake Magnitude Scale, <http://www.geo.mtu.edu/UPSeis/magnitude.html>.

<sup>70</sup> Richard Davies, quoted in “New Fracking Research Led by Durham University Rinds it is ‘Not Significant’ in Causing Earthquakes,” Durham University News, April 10, 2013, <http://www.dur.ac.uk/news/newsitem/?itemno=17347>.

As noted earlier, it is estimated that hydraulic fracturing has been used to stimulate more than one million oil and gas wells in the United States since 1947, making the incidence of earthquakes capable of being felt on the surface caused by the fissuring of deep rock formations to date, one in one million.

### ***Injection Wells and Earthquakes***

The Denver earthquakes were triggered when military wastes were injected into a hole 12,044 feet deep.<sup>71</sup> This series of earthquakes prompted further research investigating the link between injection wells and seismic activity. Although injection wells are an effective way of disposing of waste and sequestering carbon, they pose a larger risk of earthquakes than the hydraulic fracturing process itself.

Policies similar to those implemented in Ohio and Arkansas will help reduce the occurrence of manmade earthquakes triggered by injection wells.

A series of small tremors ranging from M2.4 to M4 were linked to the use of injection wells in Ohio and Arkansas in 2011. There were no reported injuries and only minor property damage occurred. The earthquakes prompted the Ohio Department of Natural Resources to promulgate rules restricting the use of injection wells. The requirements mandate drillers to submit geologic mapping data before drilling; if these data do not exist, companies must hire scientists to obtain them.<sup>72</sup> Wells also must contain state-of-the-art pressure and volume monitoring equipment, along with an automatic shutoff system in case pressures exceed the limits the state has set for each well.<sup>73</sup>

Approximately 30,000 disposal wells are used for the disposal of oil and gas waste. According to John Bredehoeft, a geological expert who has held research and management positions at the U.S. Geological Survey, the vast majority of these wells are geologically stable, and scientists believe increased data collection and monitoring can help prevent future earthquakes near injection well sites.<sup>74</sup>

As injection wells are increasingly utilized for disposal of oil and gas waste and carbon sequestration around the nation, policies similar to those implemented in Ohio and Arkansas will help reduce the occurrence of manmade earthquakes.

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<sup>71</sup> Richard Davies *et al.*, *supra* note 66.

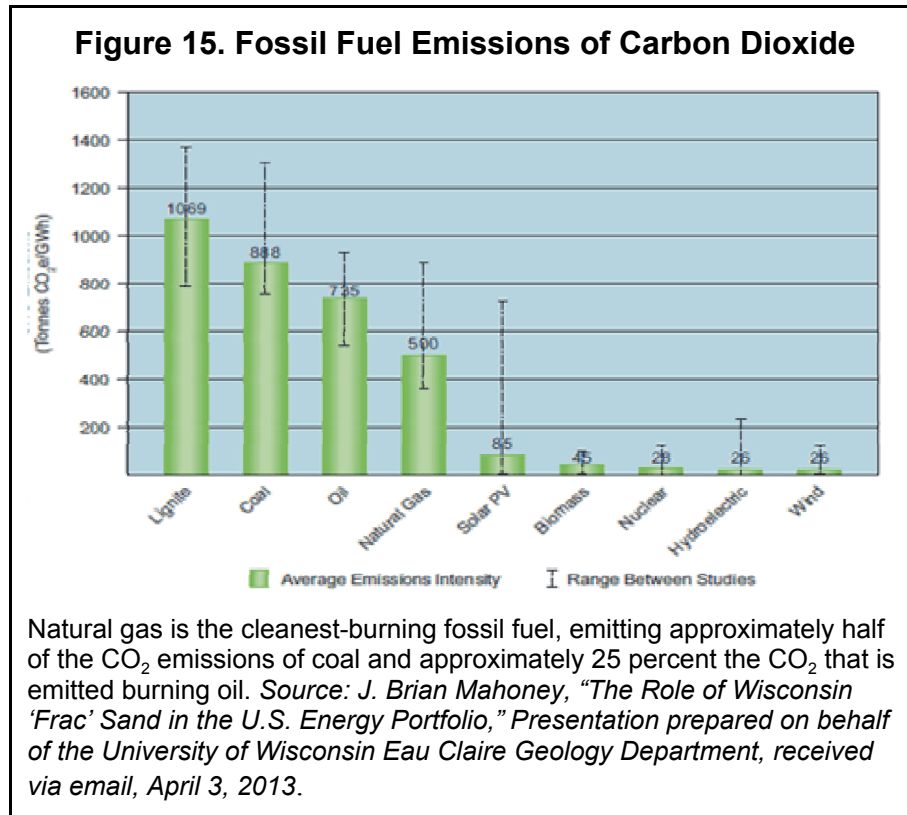
<sup>72</sup> Douglas J. Guth, "Ohio Tries to Avoid Repeat of 2011 Injection Well Quakes," *Midwest Energy News*, April 29, 2013, <http://www.midwestenergynews.com/2013/04/29/ohio-tries-to-avoid-repeat-of-2011-fracking-wastewater-injection-well-earthquakes/>.

<sup>73</sup> John Funk, "Waste-Water Injection Well Caused 12 Earthquakes in Ohio, Investigation Shows," *The Plain Dealer*, March 9, 2012, [http://www.cleveland.com/business/index.ssf/2012/03/shale\\_gas\\_drilling\\_caused\\_smal.html](http://www.cleveland.com/business/index.ssf/2012/03/shale_gas_drilling_caused_smal.html).

<sup>74</sup> *Ibid.*

## Greenhouse Gas Emissions

As natural gas prices dipped below \$2/MMBtu, power plants began to shift away from coal toward less-expensive natural gas, resulting in lower electricity prices and fewer carbon dioxide and sulfur dioxide emissions into the atmosphere. Burning natural gas emits just 1 percent as much sulfur dioxide (which at high ambient levels is linked to adverse effects on the respiratory system) as is emitted by coal.<sup>75,76</sup>



Natural gas is the cleanest-burning fossil fuel, emitting 25 percent less carbon dioxide than petroleum and approximately 50 percent fewer emissions than coal,<sup>77</sup> which is one of the main reasons natural gas historically has been praised by environmental groups looking for ways to reduce U.S. greenhouse gas emissions (see Figure 15).

Natural gas accounted for roughly 30 percent of the fuel used in electricity generation

in 2012, compared to 16 percent in 2000. Coal has fallen from 52 percent of the electricity generation market in 2000 to 38 percent in 2012. Increasing reliance on natural gas and shrinking energy demand due to a struggling economy have been key reasons why U.S. CO<sub>2</sub> emissions

<sup>75</sup> Seamus McGraw, "Is Fracking Safe? The Top 10 Controversial Claims About Natural Gas Drilling," *Popular Mechanics*, n.d. <http://www.popularmechanics.com/science/energy/coal-oil-gas/top-10-myths-about-natural-gas-drilling-6386593#slide-3>.

<sup>76</sup> United States Environmental Protection Agency, "Sulfur Dioxide," updated May 21, 2013, <http://www.epa.gov/airquality/sulfurdioxide/>.

<sup>77</sup> World Nuclear Association, *Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources*, July 2011, [http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working\\_Group\\_Reports/comparison\\_of\\_lifecycle.pdf](http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/comparison_of_lifecycle.pdf).

have fallen 12 percent since 2005, to their lowest levels since 1994.<sup>78</sup> The U.S. Department of Energy predicts carbon dioxide emissions will begin to rise again on a year-to-year basis beginning in 2015 but will not reach 2005 levels again through 2040.

Although CO<sub>2</sub> emissions have fallen as natural gas has replaced coal for electricity generation, environmental groups argue unconventional wells emit more “fugitive” methane into the atmosphere, negating the benefits derived from burning natural gas. Although many of these claims are based on discredited data, EPA regulations passed in April 2012 will soon render the argument irrelevant.

The new air quality standards will require the use of “green well completion,” a technology designed to capture 95 percent of fugitive methane emissions, by 2015 when the equipment necessary for its implementation is more widely available. Until then, producers are required to burn excess gas (also known as flaring) to remove volatile hydrocarbons.

Green completion technology is already used in 50 percent of unconventional gas wells nationwide,<sup>79</sup> and a recent study by the Massachusetts Institute of Technology found green completion technology pays for itself 95 percent of the time and would still pay for itself 83 percent of the time if the cost to

Hydraulic fracturing and the resulting shale gas boom have provided the United States a cost-effective, clean, and abundant source of fuel.

“green complete” a well were doubled, indicating that in most cases, companies would lose money by not implementing this technology.<sup>80,81</sup> These measures are expected to be so successful that Gina McCarthy, at the time assistant administrator of the EPA Office of Air and Radiation and recently confirmed as EPA administrator, stated the agency does not see a need to take further action on industry methane emissions.

Hydraulic fracturing and the resulting shale gas boom have provided the United States a cost-effective, clean, and abundant source of fuel that will stimulate economic growth while reducing greenhouse gas emissions in a practical and significant way.

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<sup>78</sup> Russell Gold, “Rise in U.S. Gas Production Fuels Unexpected Plunge in Emissions,” *The Wall Street Journal*, April 18, 2013, <http://online.wsj.com/article/SB10001424127887324763404578430751849503848.html>.

<sup>79</sup> Pam Kasey, “EPA Requires Green Completion, Cuts Pollution from Fracked Wells,” *The State Journal*, May 18, 2012, <http://www.statejournal.com/story/17526063/epa-requires-green-completion-cuts-pollution-from-fracked-wells>.

<sup>80</sup> John Hangar, “MIT Blockbuster Study Finds Shale Gas Methane Emissions Greatly Exaggerated: Shale Gas Is Cleaner Than Even EPA Number,” John Hangar’s Facts of the Day, November 30, 2012, <http://johnhanger.blogspot.com/2012/11/mit-blockbuster-study-finds-shale-gas.html>.

<sup>81</sup> Francis O’Sullivan and Peggy Paltsev, “Shale Gas Production: Potential Versus Actual Greenhouse Gas Emissions,” *Environmental Research Letters* 7 (2012), [http://iopscience.iop.org/1748-9326/7/4/044030/pdf/1748-9326\\_7\\_4\\_044030.pdf](http://iopscience.iop.org/1748-9326/7/4/044030/pdf/1748-9326_7_4_044030.pdf).

## PART 3

# Oil and Gas Regulation

Regulation of the oil and gas industries has been a shared responsibility between state and federal governments for decades, with a majority of the regulation enacted and enforced at the state level. This has resulted in a variance in regulations ranging in scope from laws that facilitate the responsible extraction of natural resources to moratoria banning the use of hydraulic fracturing.

States will be better able to tailor regulations to their specific needs, whereas standardized regulations create a one-size-fits-all system based on the “average” situation.

As hydraulic fracturing has become more prevalent, so too have calls for expanded federal oversight. According to a study by Lee Lane of the Hudson Institute, production of oil and natural gas poses a variety of challenges, some better suited for regulation by state governments, others better suited for federal regulation. Which challenges should

be handled by which level of government is a point of contention, Lane writes.<sup>82</sup>

Proponents of expanded federal authority, such as Jody Freeman, former counselor for energy and climate change for the Obama administration, argue that although some states will work proactively to create the highest standards, others will lag behind, creating a patchwork of state regulatory systems.<sup>83</sup> Freeman asserts broad public support is necessary to maintain hydraulic fracturing and standardized regulations will more effectively calm the fears of the public and protect the environment.

Although standardized regulations may sound appealing, Lane notes shale oil and gas regulations are not as easily standardized as automobile specifications or air quality regulations. Localized factors such as geology, hydrology, economics, and the difficulties that can arise from local factors in the event of potential problems such as water contamination and earthquakes are better served by state governments and agencies more familiar with the area than federal authorities, especially when these difficulties require immediate action. States will be better able to tailor regulations to their specific needs, whereas standardized regulations create a one-size-fits-all system based on the “average” situation. Regulations appropriate for the average situation are seldom appropriate in specific ones.<sup>84</sup> When problems arise in oil and gas production,

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<sup>82</sup> Lee Lane, *supra* note 23.

<sup>83</sup> Julia Bell, “Subtraction Through Addition via the FRAC ACT,” Energy In Depth, February 8, 2013, <http://energyindepth.org/national/subtraction-through-addition-via-the-frac-act/>.

<sup>84</sup> Lee Lane, *supra* note 23.

specific knowledge of a site is far more helpful than standard protocol.

Unconventional oil and gas production is a dynamic industry with advancements, and accidents, occurring rapidly, forcing industry to change practices along with them. When earthquakes caused by injection wells shook parts of Ohio and Arkansas, regulators shut down five injection wells and new construction rules were enacted requiring placement of pressure monitoring equipment in the well, forbidding drilling into basement rock, and requiring companies to provide detailed geologic information to state regulators before wells can be drilled.<sup>85</sup>

Richard Simmers, head of the Ohio Department of Natural Resources Division of Oil and Gas Resources Management, told the House Natural Resources Committee he “unequivocally” believes state regulation of oil and gas production to be the “most effective, efficient and economical.” He also testified states can respond more quickly to problems than the federal government.<sup>86</sup> States must be effective at regulating problems because they have the primary responsibility for protecting their environment, the public health, and facilitating economic growth within their borders.

As a result, state regulators must typically be more pragmatic because they do not have the luxury of inefficiency that is afforded to federal regulators. For example, enforcement and promulgation of EPA rules is partially determined by funding. When budget battles rage in Washington, EPA funding is used as a political pawn, as congressional members have learned to use the appropriations process as a potent tool for reining in some of EPA’s more costly programs.<sup>87</sup>

State regulators must typically be more pragmatic because they do not have the luxury of inefficiency that is afforded to federal regulators.

The Fracturing Responsibility and Awareness of Chemicals (FRAC) Act would increase the scope of EPA authority regarding hydraulic fracturing and require drilling companies to disclose the chemicals used in fracking fluid, but it has failed to gain any traction in Congress. On the other hand, Colorado, Texas, and Wyoming already require disclosure of fracking fluids, and 10 states – Colorado, Louisiana, Mississippi, Montana, North Dakota, Ohio, Oklahoma, Pennsylvania, Texas, and Utah – use the Web site FracFocus for official state chemical disclosure.<sup>88</sup>

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<sup>85</sup> Aaron Marshall, “New Wave of Injection Wells on the Way in Ohio for Fracking Waste,” *The Plain Dealer*, November 23, 2012, [http://www.cleveland.com/open/index.ssf/2012/11/new\\_wave\\_of\\_injection\\_wells\\_on.html](http://www.cleveland.com/open/index.ssf/2012/11/new_wave_of_injection_wells_on.html).

<sup>86</sup> Sabrina Eaton, “Federal Hydraulic Fracturing Rules Aren’t Needed, Ohio Official Tells Congressional Committee” *The Plain Dealer*, April 17, 2013, [http://www.cleveland.com/open/index.ssf/2013/04/federal\\_hydraulic\\_fracturing\\_r.html](http://www.cleveland.com/open/index.ssf/2013/04/federal_hydraulic_fracturing_r.html).

<sup>87</sup> Richard Lazarus, “Congressional Descent: The Demise of Deliberative Democracy in Environmental Law,” *The Georgetown Law Journal* 94 (Winter 2006), pp. 619-81, [http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=847648](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=847648).

<sup>88</sup> FracFocus, “About Us,” <http://fracfocus.org/welcome>.

These efforts are part of the reason Lisa Jackson, former head of EPA, acknowledged the ability of states to handle oil and gas regulation, stating, “States are doing a good job. It doesn’t have to be the EPA that regulates the 10,000 wells that might go in.”<sup>89</sup> State regulators must be quick, efficient, and practical in their actions, addressing problems as they arise. The current culture in Washington does not lend itself to quick, efficient, or practical action.

Illinois has passed the most comprehensive regulatory bill in the nation, satisfying the interests of both industry and environmental groups.

Finances are another reason states are pragmatic when it comes to oil and gas regulation. As stated previously, total government revenues from unconventional U.S. oil and gas production were more than \$62 billion in 2012. This revenue potential has caused states such as California, which

has a history of imposing strict environmental standards, to refrain from imposing a moratorium on hydraulic fracturing.<sup>90</sup> Budgetary constraints are one reason the state of Illinois has passed the most comprehensive regulatory bill in the nation, satisfying the interests of both industry and environmental groups.<sup>91</sup>

Illinois’ Hydraulic Fracturing Regulatory Act, adopted in June 2013, is one possible model for policymakers in other states.<sup>92</sup> The law establishes numerous technical criteria fracking site operators must satisfy, including a detailed permitting process where applicants must register, disclose their corporate pedigree, prove possession of \$5 million in insurance, and disclose any “serious” previous violations. Drilling applications must include the location and depth of the well, angle of the wellbore, lowest potential fresh water along the length of the entire well bore, and a detailed description of the geologic formations affected. The law also requires several plans to be submitted with the application: freshwater withdrawal and management plan; a plan for handling storage, transportation, and disposal or reuse of hydraulic fracturing fluid and hydraulic fracturing flowback; well site safety plan; containment plan; casing and cement plan; traffic management plan; and a work plan for water quality monitoring.<sup>93</sup>

The new law also establishes setbacks from schools, residences, and potable wells and prohibits the injection of benzene into fresh water. Applicants must fully disclose the chemicals and

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<sup>89</sup> Nicolas Loris, “Hydraulic Fracturing: Critical for Energy Production, Jobs, and Economic Growth,” The Heritage Foundation, August 28, 2012, <http://www.heritage.org/research/reports/2012/08/hydraulic-fracturing-critical-for-energy-production-jobs-and-economic-growth>.

<sup>90</sup> Taylor Smith, “Hydraulic Fracturing in California,” *Research & Commentary*, The Heartland Institute, June 17, 2013, <http://heartland.org/policy-documents/research-commentary-hydraulic-fracturing-california>.

<sup>91</sup> Law Offices of Carey S. Rosemarin, P.C., “Fracking in Illinois, The General Assembly Should Pass HB2615, and Reject the Proposed Moratorium,” March 19, 2013, <http://www.rosemarinlaw.com/Environmental-Law-Blog/2013/March/Fracking-in-Illinois-The-General-Assembly-Should.aspx>.

<sup>92</sup> Illinois General Assembly, Status of SB 1715, <http://www.ilga.gov/legislation/BillStatus.asp?DocNum=1715&GAID=12&DocTypeID=SB&LegID=72606&SessionID=85&SpecSess=&Session=&GA=98>.

<sup>93</sup> *Ibid.*



proppants to be used in fracking operations at least 21 days prior to the start of fracking operations, and the use of non-disclosed chemicals in the fracking fluid is prohibited. The bill also requires notification of the Illinois DNR 48 hours before fracking operations begin, and numerous tests must be satisfied before the event can take place. Air emissions must be minimized and fracking fluids must be stored in aboveground tanks until they are disposed of in Class II injection wells.<sup>94</sup>

Fracking operations must be immediately suspended if monitoring data indicate the well has been compromised. The Illinois State Geological Survey will work to develop rules to mitigate induced seismicity from Class II injection wells. The law also requires baseline data be taken in water sources within 1,500 feet of the well site prior to fracking, with continued monitoring thereafter at six months, 18 months, and 30 months.

State governments are quite able to promulgate rules that can satisfy the demands of industry and environmentalists alike.

Illinois' new law shows state governments are quite able to promulgate rigorous rules that can satisfy the demands of industry and environmentalists alike, enabling the development of natural resources while protecting the environment. There are nonetheless some areas where federal regulation is more efficient than state laws.

The federal government regulates wastewater injection wells as Class II wells under the Safe Drinking Water Act, and Underground Injection Control standards prevent the use of diesel fuel in fracking fluid and drilling mud. Natural gas and oil pipelines crossing state boundaries are regulated by the Federal Energy Regulatory Commission, and the Clean Water Act limits the discharge of pollutants into surface waters. Additionally, EPA recently enacted air quality standards, following the examples set by Wyoming and Colorado, requiring oil and gas drillers by 2015 to capture "volatile compounds" (methane, hydrocarbons, and additional particulates) from wells as they migrate up to the surface during the drilling process. In the meantime, drillers are required to flare, or burn, these gases as they flow out of wells. These factors are best regulated by the federal government because of their interstate nature, whereas additional federal regulation in intrastate matters would be unnecessary, costly, and duplicative.<sup>95</sup>

Illinois' monitoring standards will contribute to the knowledge of how hydraulic fracturing affects the environment. States that have imposed moratoria, by contrast, are not producing data or records of experience that will enable them to better understand the costs and benefits of fracking. New York's initial study, for example, concluded more study must be done, and the preliminary results have not produced the data that will be produced in Illinois.

At the time of this writing, three states have active moratoria on hydraulic fracturing: New York, North Carolina, and Vermont, even though there has never been a confirmed case of

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<sup>94</sup> *Ibid.*

<sup>95</sup> Lee Lane, *supra* note 23.

groundwater contamination caused by hydraulic fracturing and the science available does not suggest that moratoria are necessary.<sup>96,97</sup>

Although regulation of oil and gas production is important, moratoria and duplicative federal laws are unnecessary and will serve only to create extra costs.

Of the three states with moratoria, only New York, which sits on portions of the Marcellus and Utica Shales, has any notable gas reserves. The moratorium has prevented growth in the natural gas industry and the creation of thousands of jobs in New York. One economic analysis projects the incomes of those who live in the 28 New York

counties above the Marcellus Shale could grow by as much as 15 percent over the next four years if the moratorium on hydraulic fracturing were lifted.<sup>98</sup>

Although regulation of oil and gas production is important, moratoria and duplicative federal laws are unnecessary and will serve only to create extra costs. As more states enact standards agreed upon by industry and environmental groups, better practices will be developed and the laboratory of the states will identify the most efficient means of extracting oil and gas while protecting the environment.

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## PART 4

### Conclusion

The combination of hydraulic fracturing and horizontal drilling is a technological breakthrough that has transformed the energy outlook of the United States, turning once uneconomic oil and gas deposits into “America’s Shale Revolution.” Once facing the prospect of supply shortages, the United States has become the largest producer of natural gas in the world, and the nation is projected to eclipse Saudi Arabia as the top petroleum producer by 2017.<sup>99</sup> These achievements would have been impossible if not for hydraulic fracturing.

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<sup>96</sup> Senate Committee on Natural Resources and Water, Senate Committee on Environmental Quality, “The Regulation of Hydraulic Fracturing Oil and Gas Production in California,” Joint Informational Hearing, February 12, 2013, <http://sntr.senate.ca.gov/sites/sntr.senate.ca.gov/files/Hydraulic%20fracturing%20background.pdf>.

<sup>97</sup> Ben Wolfgang, “Methane Study, EPA Debunk Claims of Water Pollution, Climate Change from Fracking,” *The Washington Times*, April 29, 2013, <http://www.washingtontimes.com/news/2013/apr/29/pa-environment-agency-debunks-fracking-water-claim/?page=1>.

<sup>98</sup> Diana Furchtgott-Roth, “The Case for Fracking in New York,” *Market Watch: The Wall Street Journal*, May 9, 2013, <http://www.marketwatch.com/story/the-case-for-fracking-in-new-york-2013-05-09>.

<sup>99</sup> Peg Mackey, “U.S. to Overtake Saudi Arabia as Top Oil Producer: IEA,” Reuters, November 12, 2012, <http://www.reuters.com/article/2012/11/12/us-iea-oil-report-idUSBRE8AB0IQ20121112>.

The dramatic increase in production led to the creation of thousands of jobs in 2012, with 360,000 jobs supported directly by the oil and gas industries, 537,000 jobs in supply-industries, and 850,000 induced jobs supported by oil and gas workers spending their paychecks in the general economy at grocery stores, dentist offices, movie theaters, and auto dealerships around the country.

The combination of hydraulic fracturing and horizontal drilling is a technological breakthrough that has transformed the energy outlook of the United States.

Low energy costs have breathed new life into the American manufacturing sector, which is projected to add one million jobs by 2025, thanks to abundant and affordable oil and natural gas.

Despite the misleading theatrics seen in the movie *Gasland*, there has yet to be a confirmed case of hydraulic fracturing contaminating drinking water. There are consequences and risks associated with the production of unconventional oil and natural gas, but the costs are vastly outweighed by the benefits.

Hydraulic fracturing can be done in a safe and environmentally responsible manner. State governments are uniquely qualified to work with environmental and industry leaders to craft legislation that protects the environment while maintaining the vibrancy of the oil and gas industry without duplicative federal regulations that raise costs without significantly increasing environmental protection.

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