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Shale Revolution or Evolution: Opportunities and Challenges for Europe

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SHALE REVOLUTION OR EVOLUTION: OPPORTUNITIES AND CHALLENGES FOR EUROPE

OWEN L. ANDERSON*

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The first country to develop significant quantities of shale gas was the United States. To illustrate this development, in 2000, shale gas accounted for a mere 1 percent of total US gas production.¹ Then in 2010, shale gas accounted for 20 percent of US gas production, and by 2035 could account for 46 percent.² Technically recoverable reserves of wet natural gas in the US are estimated to exceed 2,400 trillion cubic feet, with shale gas accounting for 27 percent.³

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¹ Paul Stevens, *The ‘Shale Gas Revolution’: Developments and Changes*, CHATHAM HOUSE (Aug. 2012), http://www.chathamhouse.org/sites/files/chathamhouse/public/Research/Energy,%20Environment%20and%20Development/bp0812_stevens.pdf..

² *Id.*; TIM BOERSMA & COREY JOHNSON, TWENTY YEARS OF US EXPERIENCE: LESSONS LEARNT FOR EUROPE, IN *SHALE GAS IN EUROPE* 9, 10 (Cécile Musialski et al. eds., 2013).

³ *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations in 41 Countries Outside the United States*, U.S. ENERGY INFORMATION ADMIN., <http://www.eia.gov/analysis/studies/worldshalegas/> (last updated June 13, 2013).

In its 2013 report, the Energy Information Agency estimated world shale-gas reserves at 7,300 trillion cubic feet.⁴ Europe could be the source of part of this increase, and European development would likely lead to a further increase in estimated reserves. The UK is estimated to have 1,300 trillion cubic feet of technically recoverable shale gas in central Britain alone.⁵ Of course, technically recoverable does not mean economically recoverable, which requires sufficiently high gas prices. The United Kingdom ended its moratorium on shale-gas development after concluding that the risk of earthquakes is low and can be mitigated.

On the other hand, France still has in place a moratorium on shale gas. Poland is allowing shale-gas exploration, but Poland's geology and bureaucracy are proving to be more difficult than expected. Although exploration is proceeding, this difficulty has caused some companies to pull out of Poland. Germany is moving forward slowly with shale-gas exploration.

I. SHALE GAS—MORE EVOLUTION THAN REVOLUTION

Although shale gas is often referred to as a “revolution” or “game changer,” in reality shale gas has grown at an evolutionary pace. Shale gas was first extracted as a resource in 1821 in New York.⁶ The oil and gas industry, which has its beginnings in Titusville, Pennsylvania, in 1859, is only 165 years old, and the modern industry, which is traced to Spindletop, Texas, in 1902, is only 112 years old. The presence of large amounts of gas and oil in shale has been recognized for over 50 years.⁷ The problem has been one of how to “unlock” the oil and gas from the shale rock.⁸

If anything is revolutionary about shale, it is the manner in which shale oil and shale gas were ignored by government forecasters, experts, and major oil and gas companies. By and large, energy outlooks, published as recent as 2011 paid scant attention to shale gas. Daniel Yergin, one of the most respected oil and gas historians and forecasters, largely ignored shale gas and shale oil in *The Quest*, his seminal sequel to *The Prize*, both leading histories of the upstream oil and gas industry. The super majors were slow to invest in shale plays. For example, ExxonMobil first entered the shale gas play in 2009 (effective June 25, 2010) by acquiring XTO

⁴ This estimate is 10 percent higher than the EIA 2011 report of 6,622 trillion cubic feet. *Id.*

⁵ *New shale gas resource figure for central Britain*, BRITISH GEOLOGICAL SURVEY, <http://www.bgs.ac.uk/shalegas/#ad-image-0> (last visited Sept. 7, 2013).

⁶ *New York's Natural Gas History—A Long Story, But Not the Final Chapter*, NEW YORK DEP'T OF ENVTL. CONSERVATION, http://www.dec.ny.gov/docs/materials_minerals_pdf/nyserda2.pdf (last visited Aug. 29, 2013).

⁷ BOERSMA & JOHNSON, *supra* note 2, at 10.

⁸ Shale gas was viewed as “unrecoverable and until this past decade prohibitively expensive to extract on a full commercial scale.” Alex Trembath, Jesse Jenkins, Ted Nordhaus & Michael Shellenberger, *Where the Shale Gas Revolution Came From: Government's Role in the Development of Hydraulic Fracturing in Shale*, THE BREAKTHROUGH INST. (May, 2012), http://thebreakthrough.org/blog/Where_the_Shale_Gas_Revolution_Came_From.pdf.

Energy.⁹ Shell, on the other hand, initially invested in shale gas in the Pindale play in Wyoming in 2001, but did not achieve significant production until 2008; after expanding its shale portfolio by acquiring assets in Texas, Louisiana, and Western Canada.¹⁰

Although not well publicized, the federal government played a major role in the development of shale gas,¹¹ including experiments to stimulate gas production using nuclear bombs between 1963 and 1973.¹² Efforts to recover gas from shale began in earnest in 1976, when President Gerald Ford advocated funding research into unconventional gas development.¹³ In the 1970s, several experimental shale-gas wells were drilled with federal participation.¹⁴ In 1980, the Energy Act provided “Section 29” tax credits for unconventional gas development.¹⁵ In 1982, the United States government began funding studies by the Gas Research Institute to investigate the recovery of oil and gas from low-permeability formations.¹⁶ The Energy Research and Development Administration funded the Morgantown Energy Research Center,¹⁷ which did pioneering research in association with private industry and nine national laboratories to demonstrate and improve shale fracturing and horizontal drilling technologies.¹⁸ The results of these research efforts were shared with the oil and gas industry. In 1986, the Department of Energy, along with several private companies, air drilled a demonstration well and hydraulically fractured it into shale in West Virginia.¹⁹

⁹ Noah Brenner, *ExxonMobil and XTO complete merger*, UPSTREAM (June 25, 2010 8:44 PM), <http://www.upstreamonline.com/live/article1191144.ece>.

¹⁰ *Royal Dutch Shell plc acquires new positions in US tight gas*, SHELL GLOBAL (May 28, 2010), <http://www.shell.com/global/aboutshell/media/news-and-media-releases/2010/shell-acquires-new-positions-us-tight-gas-28052010.html>.

¹¹ Jason Burwen & Jane Flegel, *Unconventional Gas Exploration & Productivity*, AMERICAN ENERGY INNOVATION COUNCIL (March 2013), <http://americanenergyinnovation.org/wp-content/uploads/2013/03/Case-Unconventional-Gas.pdf>.

¹² See generally “Gasbuddy” Tests Nuclear Fracking, AM. OIL & GAS HISTORICAL SOC’Y <http://aoghs.org/technology/project-gasbuggy/> (last visited December 3, 2014).

¹³ In response to oil shortages resulting from the 1970’s oil crisis, the Ford administration “began a concerted federal effort to seek unconventional natural gas.” Trembath, et al., *supra* note 8.

¹⁴ *Id.*

¹⁵ These Section 29 production tax credits “provid[ed] an incentive of \$0.50 per thousand cubic feet (Mcf) of natural gas produced from unconventional resources.” *Id.*

¹⁶ Stevens, *supra* note 1, Table 1, at 9.

¹⁷ Later renamed the National Energy Technology Laboratory.

¹⁸ *Interview with Alex Crawley, Former Director of the Energy Research and Development [Administration]*, THE BREAKTHROUGH INST. (May 21, 2012), http://thebreakthrough.org/archive/interview_with_alex_crawley_fo.

¹⁹ *Testimony of Jesse D. Jenkins, Director of Energy and Climate Policy, The Breakthrough Inst., Before the Senate Comm. on Energy and Natural Res., 113th Cong. 23 (2012) (statement of Jesse D. Jenkins, Director of Energy and Climate Policy, The Breakthrough Inst.), available at*

In 1991, the Gas Research Institute subsidized Mitchell Energy's first successful horizontal well in the Texas Barnett Shale.²⁰ The late George Mitchell, son of a Greek immigrant, is considered the father of hydraulic fracturing.²¹ Mitchell graduated first in his class from Texas A&M University in 1940 with a degree in petrochemical engineering and geology.²² During his lifetime he participated in drilling about 10,000 wells, including more than 1,000 wildcat wells.²³ His company, Mitchell Energy, is credited with over 200 oil discoveries and over 350 gas discoveries.

Mitchell spent nearly two decades developing a successful hydraulic fracturing technique.²⁴ "There's no point in mincing words. Some people thought it was stupid," including "probably 90 percent of the people" in the firm.²⁵ Mitchell's company failed to recover the costs of fracking a well until its 36th shale well was drilled.²⁶ Mitchell's first economically viable shale-gas well was drilled in 1998 in the Barnett Shale.²⁷ Larry Nichols, CEO of Devon Energy, another independent, took notice of Mitchell's success and acquired the company in 2002 for \$3.1 billion, making Devon the largest player in the Barnett Shale.²⁸

While there is no established definition for "unconventional gas," the term can be used to describe any gas that is substantially more difficult and expensive to recover.²⁹ Shale gas meets these criteria because it is locked in comparatively

http://www.energy.senate.gov/public/index.cfm/files/serve?File_id=31b79a1a-83a0-4ae6-8c80-30fe754ad0ea [hereinafter *Testimony of Jesse D. Jenkins*].

²⁰ *Id.*

²¹ *Texas billionaire George P. Mitchell, the father of fracking, dies at 94*, DALLAS MORNING NEWS, <http://www.dallasnews.com/news/local-news/20130726-texas-billionaire-george-p.-mitchell-the-father-of-fracking-dies-at-94.ece> (last updated July 26, 2013) [hereinafter George P. Mitchell].

²² *Id.*

²³ *Id.*

²⁴ *Id.*

²⁵ *Id.* (quoting an Associated Press interview with Dan Steward, a geologist who began working for Mitchell in 1981).

²⁶ *Id.*

²⁷ *Testimony of Jesse D. Jenkins, supra* note 19, Figure 6, at 23.

²⁸ George P. Mitchell, *supra* note 211.

²⁹ "'Unconventional' oil and natural gas is exactly the same commodity as 'conventional' oil and natural gas. The word 'unconventional' is typically applied to major new advances in extraction technology, in the oil and natural gas industry, that allow access to resources not technically or economically recoverable." IHS, *America's New Energy Future: The Unconventional Oil and Gas Revolution and the US Economy*, INST. FOR 21ST CENTURY ENERGY 2 (2012), http://www.energyxxi.org/sites/default/files/pdf/americas_new_energy_future-unconventional_oil_and_gas.pdf [hereinafter *New Energy Future*];

Schlumberger Oilfield Glossary defines "unconventional resource" as follows:

An umbrella term for oil and natural gas that is produced by means that do not meet the criteria for conventional production. What has qualified as unconventional at any particular time is a complex function of resource characteristics, the available

impermeable rock, which complicates recovery.³⁰ Shale is porous and thus can hold oil, gas or both, but these fluids are unable to move readily within shale because the pore spaces are not sufficiently interconnected to allow for the fluids to flow.³¹ Drill cuttings from many shales in wells targeting other formations have revealed the presence of oil, gas, or both, but until recently, shale gas and oil have not been technically and economically recoverable in sufficient volumes to justify well completion in shale.³²

Two technical innovations have spurred oil and gas from shale: horizontal drilling and hydraulic fracturing.³³ A third, microseismic, has also played a role.³⁴

“Directional” or “slant” wells were intentionally drilled as early as the 1920s, sometimes to facilitate a clandestine trespass and were drilled in the 1930s to fight

exploration and production technologies, the economic environment, and the scale, frequency and duration of production from the resource. Perceptions of these factors inevitably change over time and often differ among users of the term. At present, the term is used in reference to oil and gas resources whose porosity, permeability, fluid trapping mechanism, or other characteristics differ from conventional sandstone and carbonate reservoirs. Coalbed methane, gas hydrates, shale gas, fractured reservoirs, and tight gas sands are considered unconventional resources.

Schlumberger Oilfield Glossary, SCHLUMBERGER, <http://glossary.oilfield.slb.com/en/Terms.aspx?LookIn=term%20name&filter=unconventional> (last visited Sept. 8, 2013);

Phil Chan offers this distinction between conventional and unconventional resources:

Conventional resources exist in discrete petroleum accumulations related to a localized geological structural feature and/or stratigraphic condition (typically with each accumulation bounded by a down-dip contact with an aquifer) that is significantly affected by hydrodynamic influences such as the buoyancy of petroleum in water. The petroleum is recovered through wellbores and typically requires minimal processing prior to sale.

Unconventional resources exist in hydrocarbon accumulations that are pervasive throughout a large area and that are generally not significantly affected by hydrodynamic influences (also called “continuous-type deposits”). Such accumulations require specialized extraction technology, and the raw production may require significant processing prior to sale.

Society of Petroleum Engineers et al., *Guidelines for Application of the Petroleum Resources Management System*, SOC’Y OF PETROLEUM ENG’R 128 (2011), http://www.spe.org/industry/docs/PRMS_Guidelines_Nov2011.pdf.

³⁰ Trembath et al., *supra* note 8.

³¹ True hydrocarbon “reservoirs” are not found in shale because its permeability is a million times lower than “conventional reservoir rock.” José Martínez de Hoz, Tomás Lanardonne & Alex Máculus, *Shale we Dance an Unconventional Tango?*, 6 J. OF WORLD ENERGY BUS. 179, 180 (2013).

³² “Engineers had neither the technology nor the knowledge base to cost effectively map shale expanses, drill horizontally in the formations, initiate fractures that were productive and predictable, and recover the gas resources locked in the formations.” Trembath et al., *supra* note 8 at 5.

³³ Stevens, *supra* note 1, at 2; *America’s New Energy Future*, *supra* note 29, at 2.

³⁴ See Trembath et al., *supra* note 8.

oilfield fires. But modern “horizontal” drilling is a relatively recent innovation that was made possible in the 1980s with the development of hydraulically powered motors that could be operated while leaving the drill pipe stationary in the hole, coupled with “measurement while drilling” tools that could send directional drilling data to the surface as drilling proceeded.³⁵ Horizontal drilling was used extensively in the development of the Austin Chalk oil play in south central Texas in the 1980s and 1990s.³⁶ The Austin Chalk formation contained narrow, vertical columns of oil bearing rock.³⁷ A vertical well may or may not have encountered these lenses, but a horizontal lateral borehole could encounter multiple lenses.³⁸ More recently developed rotary steering system tools allow more accurate directional control of the drilling bit.³⁹ Today, through the use of rotary steering systems, horizontal laterals can be steered quite precisely to expose the most promising portions of a target formation.⁴⁰

Hydraulic fracturing, which can be natural or man-made, is the fracturing of rock by a fluid under pressure. When done by man, water and trace amounts of chemicals, fracking fluids are injected into a wellbore under very high pressure.⁴¹ The fracturing fluids are forced by the hydraulic pressure into the targeted formation to crack or fracture it, thereby artificially enhancing permeability—facilitating the ability of

³⁵ “[L]ittle practical application occurred until the early 1980’s, by which time the advent of improved downhole drilling motors and the invention of other necessary supporting equipment, materials, and technologies, particularly downhole telemetry equipment, had brought some kinds of applications within the imaginable realm of commercial viability.” EIA., *Drilling Sideways – A Review of Horizontal Well Technology and Its Domestic Application* 7, ENERGY INFORMATION ADMIN. (1993), http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/drilling_sideways_well_technology/pdf/tr0565.pdf [hereinafter *Drilling Sideways*].

³⁶ In 1990, roughly 850 horizontal wells were drilled in this formation alone. *Id.* at 8.

³⁷ “The formation is a massive, oil-bearing limestone that, in some locations, is extensively vertically fractured.” *Id.* at 13.

³⁸ “As a consequence, horizontal wells drilled to intersect several vertical fractures at an approximate right angle have typically demonstrated much larger initial production rates than were provided by previously drilled vertical wells. The latter, of course, at best intersected only one vertical fracture.” *Id.*

³⁹ Jon Ruzska, *Rotary Steerable Drilling Technology Matures*, DRILLING CONTRACTOR, 44 (2013), <http://www.iadc.org/dcp/dc-julyaug03/July3-Rotary.pdf>.

⁴⁰ For example, in the Giddings Field of the Austin Chalk, “a lateral displacement of about 300 feet was used to reach a comparatively small area of faulted and fractured rock, with the small horizontal reach in the target formation being little beyond that achievable with a vertical well.” *Drilling Sideways*, *supra* note 35, at 14.

⁴¹ “For shale gas development, fracture fluids are primarily water based fluids mixed with additives that help the water to carry sand proppant into the fractures. Water and sand make up over 98 percent of the fracture fluid, with the rest consisting of various chemical additives that improve the effectiveness of the fracture job.” U.S. Dep’t. of Energy, *Modern Shale Gas Development in the United States: A Primer*, ES-4, (2009), http://energy.gov/sites/prod/files/2013/03/f0/ShaleGasPrimer_Online_4-2009.pdf [hereinafter *Shale Gas Primer*].

fluids to flow through the reservoir rock.⁴² Sand, ceramic beads, or other “proppants” are also injected into the fractures.⁴³ When the injected fluid is withdrawn, the proppants remain to hold the cracks or fractures open to facilitate the flow of hydrocarbons into the wellbore. Thus, hydraulic fracturing is classified as a form of well completion. Once the hydraulic fracturing operation is concluded, the hydraulic-fracturing equipment is removed from the well site and hydrocarbon production ensues. Hydraulic fracturing was first used in 1947 to extract natural gas from limestone⁴⁴ and was commercially used by 1949 to complete vertical wells.⁴⁵ Over one million wells have been hydraulically fractured in the United States.⁴⁶ Today, over 60 percent of the wells drilled in the United States are hydraulically fractured.⁴⁷

Together, horizontal drilling serves to expose more reservoir rock to the well bore, and hydraulic fracturing of the horizontal lateral of the wellbore allows a greater portion of the reservoir rock to be fractured, thus facilitating a greater recovery of hydrocarbons.

Seismology dates back to World War I, when measuring the speed of sound through the air was used to locate the positions of enemy artillery.⁴⁸ This technique was adapted for use in oil and gas exploration in Oklahoma in the 1920s.⁴⁹ When exploring for oil and gas, sound waves are used to identify favorable geologic structure or traps that might hold oil. Historically, this geophysical information was gathered only along a narrow line of subsurface. This basic geophysical exploration is generally called conventional or sometimes 2-D seismic. Today, because of the

⁴² *Id.*

⁴³ *Id.* at 61.

⁴⁴ Trembath et al., *supra* note 8.

⁴⁵ In 1949, after obtaining a patent and an exclusive license, the Halliburton Oil Well Cementing Company (Howco) performed the first two commercial fracturing treatments. 332 wells were treated in the first year, with an average production increase of 75 percent. Carl T. Montgomery & Michael B. Smith, *Hydraulic Fracturing, History of Enduring Tech.*, JOURNAL OF PETROLEUM TECH., available at <http://www.spe.org/jpt/print/archives/> (select 2010; then select February)

⁴⁶ <http://www.api.org/oil-and-natural-gas-overview/exploration-and-production/hydraulic-fracturing/hydraulic-fracturing-qa.aspx> (last visited December 20, 2014).

⁴⁷ *Id.*

⁴⁸ During World War I, seismic waves from large guns were detected at arrays of seismic stations and used to pinpoint gun emplacement sites. *The First 100 Years (1845–1945)*, GEOLOGICAL SOCIETY OF AM. MEMOIRS 47, 48 (2012), [http://escweb.wr.usgs.gov/share/mooney/143/Geological-Society-of-America-Memoirs-2012-Articles-2012.2208\(03\).pdf](http://escweb.wr.usgs.gov/share/mooney/143/Geological-Society-of-America-Memoirs-2012-Articles-2012.2208(03).pdf).

⁴⁹ In 1920, John Clarence Karcher and William P. Haseman “organized the Geological Engineering Company and began field operations in Oklahoma. The first field tests were conducted near Oklahoma City, Oklahoma, in 1921.” Although the company soon folded due to a drop in the price of oil, Karcher went on to help establish Geophysical Service Incorporated (GSI), which was “one of the most successful seismic contracting companies for the following 50 years and was the parent of an even more successful company, Texas Instruments.” *Id.* at 52.

development of modern computers that can process large amounts of data in a short amount of time, geophysical information can be gathered over a grid, called 3-D seismic. And thanks to the development of more sophisticated geophones (listening devices), processed seismic data can even reveal the probable presence of hydrocarbons.⁵⁰ Additional microseismic data can be gathered through a monitor well bore that can determine the location, extent, and pattern of hydraulic fracturing to allow adjustments to be made during the fracturing operation and microseismic can also measure the behavior of the reservoir over its productive time—4-D seismic—to determine the need for additional drilling or fracturing to increase ultimate recovery.⁵¹

Unfortunately, shale gas has become the victim of its own success.⁵² Increased domestic gas production, coupled with economic recession beginning in 2008, has caused gas prices to plummet from over \$13 per million British Thermal Units (mmBTU) to less than \$2.50 in 2012.⁵³ When this article was written in July of 2013, natural gas was priced at about \$3.60 per mmBTU.⁵⁴ This price decline has resulted in less enthusiasm for more costly renewable forms of energy and caused drilling to decline in shale-gas formations that contain dry gas and to increase in shale-oil formations and in shale-gas formations that are rich in natural gas liquids (NGLs).⁵⁵ Construction of facilities to regasify LNG imports into the United States has been put on hold in favor of LNG liquefaction facilities, which will allow for the export of natural gas from the United States to regions of the world where gas prices are

⁵⁰ Geophones have become extremely sensitive. “To give you an idea of the sensitivity, we have to stop seismic recording if winds get up to, say, 20 miles an hour or higher. The reason is the wind shakes the grass and affects the signal. It just builds up background noise in the geophones that is undesirable. A small insect, even an ant, can crawl across the top of a geophone, and it’ll generate noise in that geophone. So they’re really extremely sensitive devices.” Bob Hardage, *Using Seismic Tech. in Oil and Gas Exploration*, EARTHSKY (2013), http://earthsky.org/earth/bob-hardage-using-seismic-technologies-in-oil-and-gas-exploration_.

⁵¹ Fiber optic monitoring technology and wireless wellbore monitoring are used to gather more data and maximize recovery. Garth Naldrett, *Downhole monitoring, control using digital distributed sensing*, OFFSHORE MAG. (Mar. 1, 2010), <http://www.offshore-mag.com/articles/print/volume-70/issue-3/production-operations/downhole-monitoring-control-using-digital-distributed-sensing.html>; *LinX Wireless Through-Wellbore Monitoring*, LINX <http://innovate.statoil.com/StatoilTechnologyInvest/Documents/Sensor%20Developments.pdf> (last visited Aug. 26, 2013).

⁵² “[G]as prices over the medium term are likely to settle within a \$4-6 per mmBTU band, still well below levels prior to the North American shale gas boom.” Alex Trembath & Jesse Jenkins, *Gas Boom Poses Challenges for Renewables and Nuclear*, THE BREAKTHROUGH INST. (2012), http://thebreakthrough.org/blog/Gas_Boom_Challenges_Renewables_Nuclear.pdf.

⁵³ *Id.*

⁵⁴ For current and historical natural gas prices, see the EIA’s Natural Gas Weekly Update, available at <http://www.eia.gov/naturalgas/weekly/>.

⁵⁵ “[T]he combination of low-cost natural gas and declining federal incentives will make it more difficult for renewable technologies like wind and solar to compete in electricity markets without subsidy, except in relatively constrained locations. Meanwhile, any American nuclear renaissance will be hard to sustain if gas prices remain low and the capital requirements of nuclear plants do not fall significantly.” Trembath et al., *supra* note 8.

higher, such as Asia—especially Japan where LNG prices were about \$15.75 per mmBTU in September 2013.⁵⁶

Many environmental groups strongly oppose hydraulic fracturing on multiple grounds. Of foremost concern is the potential that fluids used in the hydraulic fracturing operation or the resulting gas production could contaminate freshwater. Given the depth of shale-gas wells relative to freshwater supplies (typically, thousands of feet of rock separate shale reservoirs and fresh groundwater resources)⁵⁷ and modern well cementing and casing practices, these concerns are greatly exaggerated.⁵⁸ But it is possible that a failed cement job on a well or migration of fracturing fluids or gas into older improperly plugged wells could contaminate freshwater. To date, no such pollution has been proven.⁵⁹

Secondly, the disposal of fracturing fluids is controversial. Injection of fracturing fluids into over-pressurized disposal wells has been blamed for small earthquakes in Arkansas and Oklahoma, as well as in a few other locations. This concern appears to be valid in a few areas where large injection volumes are suspected of making long dormant faults more “slippery,” resulting in small earthquakes that have caused some minor isolated damage to nearby buildings.⁶⁰ Surface disposal of fracturing fluids is also controversial due to concerns that existing treatment facilities are unable to remove all pollutants.⁶¹

Thirdly, the volume of freshwater used in hydraulic fracturing is controversial, especially in arid and semi-arid regions. Each well requires several million gallons of water.⁶² Although this amount is relatively small, when this per-well amount is multiplied by thousands of wells, water use is significant.⁶³ Solving this issue

⁵⁶ *Natural Gas Overview; World LNG Prices, World LNG Estimated September 2013 Landed Prices*, FED. ENERGY REG. COMM’N, <http://www.ferc.gov/market-oversight/mkt-gas/overview/ngas-ovr-lng-wld-pr-est.pdf> (last updated Aug. 15, 2013).

⁵⁷ Shale Gas Primer, *supra* note 41, at ES-4.

⁵⁸ Typically, water aquifers exist at a depth of only 500 feet. Shale-gas wells, on the other hand, are drilled to depths of roughly 6,000-10,000 feet. Peter C. Glover, *Ten Fracking Things Everyone Should Know*, ENERGY TRIBUNE (2011), <http://www.energytribune.com/7499/ten-fracking-things-everyone-should-know#sthash.KaxHILh7.dpbs>.

⁵⁹ In fact, both the EPA and Energy Secretary Ernest Moinz have found no evidence that fracking, per se, causes ground water pollution. Moinz has publically stated that fracking is not only safe, but should be used. Sean Higgins, *Energy Secretary: Fracking is safe*, WASH. EXAM’R (2013), <http://washingtonexaminer.com/energy-secretary-fracking-is-safe/article/2533758>.

⁶⁰ Injection of shale-gas fluids into underground wells is regulated by the Underground Injection Control Program created by the Safe Drinking Water Act and state agency rules and regulations. Shale Gas Primer, *supra* note 41, at 25, 32.

⁶¹ As of 2009, “there were plans to construct commercial waste water treatment facilities specifically designed for the treatment of produced water associated with shale gas development in some locations around the country.” *Id.* at 68-70. Additionally, “[n]ew water treatment technologies and new applications of existing technologies are being developed and used to treat shale gas produced water.” *Id.* at 68.

⁶² *Id.*

includes recycling and reuse of fluids and perhaps developing a means of fracturing that uses substantially less water.⁶⁴

Fourthly, the hydraulic-fracturing operation causes additional pollution, including the emission of greenhouse gases while the operation is occurring and the increase of noise in the surrounding area.⁶⁵ These problems can be addressed through better containment but cannot be completely eliminated.

Fifthly, the environmental community is very concerned that shale gas will displace renewables such as wind and solar that emit no greenhouse gases.⁶⁷ The fact that natural gas is much cleaner burning than coal provides little solace because they argue that the total carbon footprint of shale gas may not be significantly less than other fossil fuels.⁶⁸

All of the above concerns will have a greater impact in Europe than they have in the United States—matters that will be further explored in the following section. Will European shale gas be developed as rapidly as it has in the United States? If one considers that shale gas took about 30 years to develop from an experimental demonstration into a fast developing commercial enterprise, it should not take that long in Europe. Indeed, the United Kingdom, after lifting its moratorium on hydraulic fracturing, appears to be moving quite rapidly. Poland is actively promoting shale gas but so far without economic production. On the other hand, if one considers how rapidly shale gas has expanded in the United States since 2003 and how rapidly investment in shale gas has declined in the past few years due to low natural gas prices in the United States, then Europe is unlikely to have either experience. The reasons will be discussed in the ensuing section.

⁶³ However, “water use for shale gas development will range from less than 0.1 percent to 0.8 percent of total water use by basin.” *Id.*

⁶⁴ Today, some wells are being fractured with gas liquids, rather than water. After production is complete, the natural gas liquids can be recovered and sold. Ingrid Lobet, *Hold the water: Some firms fracking without it*, HOUSTON CHRONICLE (2013), available at <http://fuelfix.com/blog/2013/08/26/hold-the-water-some-firms-fracking-without-it/>.

⁶⁵ It is important to remember, however, that the shale-gas industry is regulated by the EPA and the standards it sets. Pollution is also stemmed by voluntary avoidance, minimization, and mitigation strategies.

Shale Gas Primer, *supra* note 41, at ES-4.

⁶⁶ The “reduced number of horizontal wells needed coupled with the ability to drill multiple wells from a single pad has significantly reduced surface disturbances and associated impacts to wildlife, dust, noise, and traffic.” *Id.*

⁶⁷ In response to this argument, Energy Secretary Ernest Moinz argues that natural gas production does not displace renewables, but instead aids it by allowing development of renewable energy technology. Higgins, *supra* note 59.

⁶⁸ Compared to coal, natural gas power generation emits half as much carbon dioxide, less than a third as much nitrogen oxides, and a mere 1 percent as much sulfur oxides. U.S. ENVIRONMENTAL PROTECTION AGENCY, <http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html> (last visited Aug. 30, 2013).

II. WHY WILL EUROPEAN SHALE GAS EVOLVE MORE SLOWLY THAN IN THE UNITED STATES?

A. Risk-Taking Independents, Known Geology, Lower Political Risk

As alluded to in the prior section, shale-gas and shale-oil booms in the United States were started by independent wildcatters, not majors and super majors. Independents tend to be more nimble since many are closely held companies. Many have high tolerance for risk, and closely held companies do not have to respond to shareholders seeking a fast return.⁶⁹ Indeed, an old saying in the United States is that independents are good at finding oil and gas, while majors are good at developing what independents find.

George Mitchell's pioneering efforts in shale gas have already been discussed. A key and early player in the Bakken oil shale play in North Dakota was Continental Resources of Enid, Oklahoma.⁷⁰ Although Continental is a publicly traded company, the majority of the stock is owned by its CEO, Harold Hamm. Brigham Exploration Company was another early entry. After proven success in the Bakken, Statoil, the partially privatized Norwegian National Oil Company, acquired Brigham and its Bakken assets in 2011.⁷¹ ExxonMobil acquired XTO Energy, Inc. in 2009 (effective June 25, 2010), maintaining it as a subsidiary.⁷² XTO, one of the nation's largest producers of natural gas, is heavily invested in shale-gas and shale-oil plays in Arkansas, Colorado, Louisiana, New York, North Dakota, Ohio, Pennsylvania, and Texas.⁷³ In 2011, ExxonMobil's CEO, Rex Tillerson, had to defend the decision to buy XTO before angry shareholders.⁷⁴

In 2011, BHP Billiton, the world's largest mining company, acquired Petrohawk Energy, along with its shale-gas resources in Texas and Louisiana.⁷⁵ Earlier in 2011,

⁶⁹ George Mitchell, the father of hydraulic fracturing, held controlling interest in his company. Harold Hamm controls Continental Resources, a major player in the Bakken shale-oil play. On the other hand, the CEOs of Chesapeake Energy Corporation and SandRidge Energy, Inc. were dismissed by shareholders when the price of natural gas declined below the point where shale-gas investment was profitable.

⁷⁰ The company relocated its corporate headquarters to Oklahoma City in 2012.

⁷¹ *Statoil enters Bakken and Three Forks oil plays through cash acquisition of Brigham Exploration Co.*, STATOIL, <http://www.statoil.com/en/newsandmedia/news/2011/pages/xxx16oct2011.aspx> (last visited Sept. 3, 2013).

⁷² Steve Gelsi, *Exxon Mobil to buy XTO Energy in \$41 billion deal*, MARKET WATCH, <http://www.marketwatch.com/story/exxon-mobil-to-buy-xto-energy-in-41-billion-deal-2009-12-14?pagenumber=1> (last visited, December 4, 2014).

⁷³ *Id.*

⁷⁴ David Koenig, *Exxon Mobil CEO defends move into natural gas*, HOUSTON CHRONICLE (2011), available at <http://www.chron.com/business/article/Exxon-Mobil-CEO-defends-move-into-natural-gas-1692711.php>

⁷⁵ Soraya Permatasari & Elisabeth Behrmann, *BHP to Acquire Petrohawk For \$12.1 Billion, Betting Natural Gas Will Climb*, BLOOMBERG (2011), <http://www.bloomberg.com/news/2011-07-14/bhp-agrees-to-purchase-petrohawk-energy-for-12-1-billion-in-all-cash-deal.html>.

BHP acquired Chesapeake Energy's Fayetteville shale-gas assets, including a midstream pipeline.⁷⁶

As previously mentioned, George Mitchell, the father of hydraulic fracturing, held controlling interest in his company, Mitchell Energy, and was thus able to experiment with the technology in shale for nearly a decade, finally achieving profitable production with the 36th well.⁷⁷ A publicly traded company with diverse ownership would most likely have faced a shareholder revolt at such a speculative and seemingly unprofitable investment. Indeed, Mitchell's own Board of Directors voted against financing shale exploration until Mitchell reminded the Board that he controlled the company.⁷⁸

While shale oil and shale gas have now been proven to be economically viable in several major basins in the United States,⁷⁹ the geology of shale can be challenging because it varies from play to play.⁸⁰ For example, challenging geology has been a problem in establishing profitable shale-gas production in Poland.⁸¹ In the United States, much shale production occurs from relatively shallow formations⁸² that have been drilled by operators seeking deeper conventional production.⁸³ Geophysical data is also available for these areas. Thus, at least in some plays, such as those in

⁷⁶ *BHP Billiton Buys Chesapeake's Fayetteville Shale Interests*, PIPELINE AND GAS JOURNAL (2011), http://www.pipelineandgasjournal.com/bhp-billiton-buys-chesapeake%E2%80%99s-fayetteville-shale-interests_

⁷⁷ George P. Mitchell, *supra* note 21.

⁷⁸ Jim Pierobon, *How He Founded Shale Gas*, THE ENERGY COLLECTIVE (2013), <http://theenergycollective.com/jimpierobon/257691/george-p-mitchell-founder-shale-gas-here-s-how-he-and-his-team-did-it> (last visited Dec. 12, 2014)

⁷⁹ Examples include the Barnett Shale in the Fort Worth Basin, Texas, the Marcellus Shale Play in the Appalachian Basin, the Woodford Shale Play in the Arkoma, Anadarko & Ardmore Basins in Oklahoma and Texas, and the Bakken Shale Play in the Williston Basin, North Dakota. For detailed shale-gas data in these basins, see EIA Exploration, Resource, Reserve, and Production maps, available at http://www.eia.gov/pub/oil_gas/natural/maps/maps.htm (last visited Sept. 5, 2013).

⁸⁰ See generally RPSEA Final Report 07122.17.01 Geological Foundation for Production of Natural Gas from Diverse Shale Formations, Contract 07122-17 (D.O.E. July 30, 2011), <http://www.netl.doe.gov/File%20Library/Research/Oil-Gas/Natural%20Gas/shale%20gas/07122-17-final-report.pdf>

⁸¹ Because European shale is generally found at depths greater than US Shale (roughly 1.5 times), costs associated with drilling, pumping and fracking are more expensive. Indeed, "drilling a gas well in Poland costs almost three times as much as in the US: \$11 million compared to \$3.9 million for a depth of 2000 meters." Nigel Smith, *Geology and Logistics Issues in a Densely populated Area*, SHALE GAS IN EUROPE, 273, 285 (Cécile Musialski et al. eds., 2013).

⁸² For example, the Barnett Shale in the Fort Worth Basin, Texas is found at depths ranging from 5,000-8,000 feet. Universal Royalty Co., *History of the Barnett Shale*, <http://www.universalroyaltyco.com/resources/history-barnett-shale/> (last visited January 8, 2015).

⁸³ When this author worked as a regulatory attorney for the State of North Dakota in the 1970s and 80s, the state's Geological Survey collected drill cuttings, core samples, and other data about the Bakken because deep wells bores were drilled through the Bakken.

Texas, Louisiana, and North Dakota, much is already known about the geology.⁸⁴ Far less is known about shale formations in Europe.

In Europe, political risk is greater, largely due to a more influential environmental lobby,⁸⁵ but also due to the European Union's style of federalism, which could result in EU regulatory initiatives designed to halt shale-gas development. Finally, the costs of developing shale gas in Europe could be substantially more expensive than continued development of established shale plays elsewhere.⁸⁶ Thus, European shale gas may be best pursued by large independents, majors, and super majors, but these are the very companies unlikely to persevere through what may be a long trial-and-error period.

B. Larger and More Experienced Petroleum Services Industry

The United States has a large and experienced petroleum services industry. Its petroleum labor force is large, highly trained, experienced, and competitively priced. By and large, labor unions are not much of a factor in the United States upstream petroleum sector. Over the years, United States service companies have developed new and improved technologies to facilitate precise horizontal drilling and highly effective hydraulic fracturing.⁸⁷ While the larger service companies have foreign offices, including offices in Europe, many smaller companies work only in the United States.

Worldwide, about 3,500 rotary drilling rigs are in service.⁸⁸ Of these, about half are working in the United States, although not all are capable of drilling horizontally.⁸⁹ To develop shale plays, many wells have to be drilled. For example, in the Bakken shale-oil play, eight or more horizontal wells may be drilled on a 1,280-acre drilling unit, not including monitoring wells that are used to determine whether additional hydraulic fracturing is needed in discreet portions of the lateral wellbore. In the Bakken shale play alone, drilling could eventually total about 40,000

⁸⁴ "The most comprehensive research regarding the Marcellus and other organic-rich shales in the Appalachian basin was published as part of the U.S. Department of Energy's Eastern Gas Shales Project (EGSP) in the late 1970s and early 1980s and by the Gas Technology Institute in Chicago during the mid 1980s to late 1990s." *Marcellus Shale*, PA. DEPT. OF CONSERVATION AND NATURAL RES., http://www.dcnr.state.pa.us/topogeo/econresource/oilandgas/marcellus/marcellus_faq/marcellus_shale/index.htm (last visited Sept. 5, 2013).

⁸⁵ *Id.*

⁸⁶ *Id.*

⁸⁷ Drill time per well in many United States plays has dropped dramatically. In the Eagle Ford, drill time per well has been reduced from 23 days in 2011 to 19 currently. In the Bakken, drill time per well was reduced 30 days between 2004 and 2009. Smith, *supra* note 81, at 284.

⁸⁸ *Id.*

⁸⁹ Baker Hughes data indicates that in July 2013, there were 1766 rigs working in the United States, 338 rigs working in Canada, and 134 rigs working in Europe. Outside of the United States and Canada, the rig count for the rest of the world was 1,292. *Worldwide Rig Counts*, BAKER HUGHES (Aug. 7, 2013), http://phx.corporate-ir.net/phoenix.zhtml?c=79687&p=irol-rigcountsintl_

wells.⁹⁰ Just maintaining production rates in shale plays requires almost constant drilling. Any lapse in drilling will cause production rates and producible reserves to decline rapidly.⁹¹ Due to declining natural gas prices, much less drilling has occurred in shale-gas plays that produce only dry gas. Declines in oil prices will result in a similar decline in well drilling in shale-oil and shale wet (liquid rich) gas plays.

In the oil and gas context, a synonym for “unconventional” is “expensive.” Drilling, fracturing, and other well services are likely to be more expensive in Europe. The North Sea has historically been one of the most expensive places to drill for oil and gas.⁹² Thus, profit margins are likely to be squeezed in Europe even though natural gas prices may be higher.

C. More Robust Infrastructure

In some of the larger shale plays in the United States, producers have been able to use existing gathering, transportation, and processing infrastructure—all of which are extensive in areas that have recent conventional production. In addition, local skilled labor is more readily available. Using and adding to existing infrastructure has become especially important during the present state of low natural gas prices. Shale-gas deposits that are rich in natural gas liquids are still profitable, but depend upon processing facilities that extract the valuable liquids.

An exception in the United States is the Bakken oil play in North Dakota. There, much of the crude oil is transported by rail—a far riskier means of transport than a crude-oil pipeline.⁹³ In addition, a large portion of associated natural gas is flared. This has created what has come to be called Bakken City. On clear nights, the flares have been photographed from satellite cameras. The photos show what appears to be a very large city in what is really a sparsely populated rural area.⁹⁴ While efforts are

⁹⁰ Javier E. David, *Bakken Emerges as Contender for US Oil Drilling Crown*, CNBC (Mar. 23, 2013), available at <http://www.cnbc.com/id/100579131>.

⁹¹ For example, a decline in rigs from 210 on October 19, 2012 to 181 on November 30, 2012 caused a 2.2 percent drop in North Dakota’s Bakken production to 669,000 barrels per day. Dan Murtaugh, *Bakken Oil Output Fell in Nov. for First Time in 18 Months*, BLOOMBERG (Jan. 11, 2013), available at <http://www.bloomberg.com/news/2013-01-11/bakken-oil-output-fell-in-november-for-first-time-in-18-months.html>.

⁹² British energy company Dana Petroleum is currently in the middle of a nine well development project, costing \$1.6 billion. *Drilling program in North Sea starts early*, UNITED PRESS INT’L (Sept. 3, 2013), http://www.upi.com/Business_News/Energy-Resources/2013/09/03/Drilling-program-in-North-Sea-starts-early/UPI-57021378209882/. See generally, *The North Sea: Running on Fumes* (The Economist, March 1, 2014) (“Meanwhile costs are spurting upwards: it is nearly five times more expensive to extract a barrel of North Sea oil than it was in 2002.”), <http://www.economist.com/news/britain/21597890-scottish-nationalists-are-right-charge-britain-has-mismanaged-north-sea-oil-unionists>.

⁹³ In summer 2013, roughly 675,000 barrels of Bakken crude were transported by rail, averaging 1,000 railcars per day. Amy Dalrymple, *N.D. oil relies on rail: Deadly derailment involved train carrying Bakken crude*, THE JAMESTOWN SUN (July 9, 2013), available at <http://www.jamestownsun.com/event/article/id/190394/>.

⁹⁴ For satellite images of “Bakken City,” see *Mystery ‘city’ caught on stunning time-lapse video from space revealed to be massive Midwest oil field*, DAILY MAIL (Nov. 16, 2011),

underway to curb flaring in the Bakken,⁹⁵ it is hard to imagine that Europe would allow such waste of natural gas should drilling in Europe lead to shale-oil production. Although higher European natural gas prices will better support installation of infrastructure, construction will take time.

Owing to the regulatory and political hurdles that will have to be jumped in order to install processing facilities to capture natural gas liquids and to secure rights-of-way for pipelines, especially cross-border lines, it will likely take much longer to install much-needed infrastructure to gather, transport, and process natural gas. Moreover, the European environmental community is likely to use its influence to block all efforts to facilitate the use of natural gas from hydraulically fractured wells.

D. Less Radical Environmental Community

As a whole, the American population and hence its politicians are becoming less concerned with climate change.⁹⁶ While the United States has a strong environmental community, it is less radical and somewhat less influential than its European counterparts. For example, Greenpeace led a successful boycott of Shell service stations to force Shell to abandon its plans to scuttle the Brent Spar platform in the North Sea.⁹⁷ In contrast, efforts to boycott BP service stations in the United States as punishment for the Macondo oil spill had little real impact in the United States.⁹⁸ Notwithstanding industry complaints to the contrary, the United States environmental community is both less radical and less influential compared to European groups. Indeed, the Environmental Defense Fund is actually in favor of more natural gas development in the United States to lessen the use of much dirtier coal.⁹⁹ The Fund favors stronger regulation of hydraulic fracturing, but this is, in part, due to its desire to minimize the chance of pollution that could cause a backlash against shale gas and hydraulic fracturing.¹⁰⁰

available at <http://www.dailymail.co.uk/sciencetech/article-2061833/Bakken-oil-field-North-Dakota-mystery-city-lit-time-lapse-video-space.html>.

⁹⁵ In July of 2014, the North Dakota Industrial Commission, which regulates oil and gas conservation, acted to restrict the flaring of gas in the Bakken play. N.D. Indus. Comm'n, Order 24665 (Jul. 1, 2014).

⁹⁶ There is some irony in this statement; however, as Europe is the largest consumer of fossil fuels in the world and uses a great deal of coal, the dirtiest of the fossil fuels. Lyle Scruggs & Salil Benegal, *Declining public concern about climate change: Can we blame the great recession?*, GLOBAL ENVIRONMENT CHANGE (in press) , <http://sp.uconn.edu/~scruggs/gec11.pdf>.

⁹⁷ 1995 - Shell reverses decision to dump the Brent Spar, GREENPEACE (Sept. 13, 2011), <http://www.greenpeace.org/international/en/about/history/Victories-timeline/Brent-Spar/>

⁹⁸ Boycotts of the roughly 13,000 BP gas stations failed because BP had sold its retail gas business years before the spill. The gas stations owners were largely independent franchisees. Yuki Noguchi, *Gas Station Owners Pay The Price For BP Affiliation*, NPR (2010), <http://www.npr.org/templates/story/story.php?storyId=127747890>.

⁹⁹ NRDF official natural gas policy, states that "[n]atural gas can be a beneficial energy resource if produced in a manner that is good for public health and the environment." *Natural Gas Policy*, ENVTL. DEF. FUND, <http://www.edf.org/energy/natural-gas-policy> (last visited Sept. 5, 2013).

¹⁰⁰ The EDF has been publically criticized by roughly 70 environmental groups for its support of hydraulic fracturing. Lenny Bernstein, *Environmental Defense Fund Scolded by*

The European environmental community will fight hydraulic fracturing with great zeal. Indeed, the community, by aligning with farmers, has barred hydraulic fracturing in France¹⁰¹ and Bulgaria.¹⁰² Moreover, the European Union may weigh in with regulations or duties designed to make hydraulic fracturing more difficult.

Environmentalists attack hydraulic fracturing on many fronts: the danger of fractures creating a direct path into fresh groundwater; the danger of fracturing fluids entering fresh groundwater through well bores that are improperly cemented; the danger of withdrawn fracturing fluids being disposed of improperly; air and noise pollution from the fracturing operation; the escape of natural gas and other pollutants from the wellhead; concerns about the high volumes of water needed to conduct hydraulic fracturing operations; and earthquakes caused by fracturing operations or by fracturing-fluids disposal operations.¹⁰³

Although experience in the United States has shown that these risks are low,¹⁰⁴ especially when compared with the total environmental footprint of coal, this will not stop the European environmental community from zealously trying to ban hydraulic fracturing. Indeed, groups such as Greenpeace and more radical organizations may even resort to trespass, violent protest, and other forms of civil disobedience to prevent hydraulic fracturing. Even in the United Kingdom, where hydraulic fracturing has received the backing of the Cameron administration,¹⁰⁵ a member of parliament and the Green Party, was arrested in August 2013 for blocking road access to a shale-gas exploration site.¹⁰⁶

Other Green Organizations on 'Fracking', WASH. POST (May 22, 2013), available at http://articles.washingtonpost.com/2013-05-22/national/39441658_1_oil-companies-energy-companies-kennedy-jr.

¹⁰¹ After mass protests by green groups across the country, French politicians voted 176-151 in favor of banning fracking on July 1, 2011, becoming the first country to declare fracking illegal. Tara Patel, *France Vote Outlaws 'Fracking' Shale for Natural Gas, Oil Extraction*, BLOOMBERG (July 1, 2011), <http://www.bloomberg.com/news/2011-07-01/france-vote-outlaws-fracking-shale-for-natural-gas-oil-extraction.html>.

¹⁰² Six months later Bulgaria became the second country to ban fracking. Elizabeth Konstantinova & Joe Carroll, *Bulgaria Bans Gas Fracking, Thwarting Chevron Drilling Plan*, BUSINESSWEEK (Jan. 19, 2012), available at <http://www.businessweek.com/news/2012-01-19/bulgaria-bans-gas-fracking-thwarting-chevron-drilling-plan.html>.

¹⁰³ WHAT GOES IN AND OUT OF HYDRAULIC FRACTURING, <http://www.dangersoffracking.com/> (last visited Sept. 4, 2013).

¹⁰⁴ Over one million wells in the United States have been hydraulically fractured. Am. Energy Inst., *Hydraulic Fracturing Q & A's*, AM. ENERGY INST., <http://www.api.org/oil-and-natural-gas-overview/exploration-and-production/hydraulic-fracturing/hydraulic-fracturing-qa.aspx> (last visited Sept. 6, 2013).

¹⁰⁵ *Fracking Should Get Public Support, Says David Cameron*, BBC, <http://www.bbc.co.uk/news/uk-politics-23662583> (last updated Aug. 12, 2013).

¹⁰⁶ Fiona Harvey & Peter Walker, *Caroline Lucas Among Dozens Arrested in Balcombe Anti-fracking Protest*, THE GUARDIAN (Aug. 19, 2013), available at <http://www.theguardian.com/environment/2013/aug/19/caroline-lucas-arrest-balcombe-anti-fracking>.

In contrast, New York is the only state to have banned hydraulic fracturing where such a ban has any practical significance.¹⁰⁷ The ban is significant because of New York's proven wet natural gas reserves, which in 2011 were estimated to be 253 billion cubic feet.¹⁰⁸ Vermont, which has also banned hydraulic fracturing,¹⁰⁹ has no proven oil and gas reserves.¹¹⁰ Maryland has a hold on applications to drill wells pending completion of a study on hydraulic fracturing,¹¹¹ but Maryland has no proven oil and gas reserves.¹¹²

E. Less Regulation

Oil and gas regulation is largely state based in the United States. States with large production are dependent upon oil and gas taxes for revenues.¹¹³ Thus, state regulatory initiatives balance health, safety, and environmental concerns with economic factors. Nevertheless, no evidence suggests that states are "racing to the regulatory bottom" to get oil and gas investment. The Interstate Oil and Gas Compact Commission, established in 1935 to forestall more federal regulation, promotes model conservation laws and assists states in establishing effective regulations.¹¹⁴

The Federal Energy Policy Act of 2005 excluded hydraulic fracturing from federal jurisdiction under the Clean Water Act, Clean Air Act, and Safe Drinking Water Act.¹¹⁵ Moreover, although several studies are ongoing, scientific studies have

¹⁰⁷ *Citing Health Risks, Cuomo Bans Fracking in New York State*, NEW YORK TIMES (Dec. 17, 2013) available at <http://www.nytimes.com/2014/12/18/nyregion/cuomo-to-ban-fracking-in-new-york-state-citing-health-risks.html>; Paula Dittrick, *New York Appeals Court Says Towns Can Ban Hydraulic Fracturing*, OIL & GAS JOURNAL (May 2, 2013), <http://www.ogj.com/articles/2013/05/new-york-appeals-court-says-towns-can-ban-hydraulic-fracturing.html>.

¹⁰⁸ U.S. Energy Information Admin., *U.S. Crude Oil and Natural Gas Proved Reserves*, EIA INDEPENDENT STATISTICS & ANALYSIS (Aug. 1, 2013), <http://www.eia.gov/naturalgas/crudeoilreserves/>.

¹⁰⁹ *Vermont Fracking Ban: Green Mountain State Is First In U.S. To Restrict Gas Drilling Technique*, HUFFINGTON POST GREEN, http://www.huffingtonpost.com/2012/05/17/vermont-fracking-ban-first_n_1522098.html (last updated May 18, 2012).

¹¹⁰ U.S. Energy Information Admin., *supra* note 108.

¹¹¹ Tim Wheeler, *Greens urge 'fracking' ban in Maryland*, THE BALTIMORE SUN (Sept. 12, 2012), available at <http://www.baltimoresun.com/features/green/blog/bal-bmg-legislative-fracking-ban-in-maryland-proposed-20120912,0,6855106.story>.

¹¹² U.S. Energy Information Admin., *supra* note 108.

¹¹³ Texas is expected to receive \$4.2 billion in oil and gas tax revenue for the 2013 fiscal year alone. See Meagan Baker, *Texas Oil and Gas Generate \$900 Million in New Tax Revenue*, ENERGY IN DEPTH (Aug. 6, 2013), <http://energyindepth.org/texas/texas-oil-and-gas-generate-900-million-in-new-tax-revenue/>.

¹¹⁴ *What We Do*, INTERSTATE OIL & GAS COMPACT COMM'N, <http://www.iogcc.state.ok.us/what-we-do>

¹¹⁵ Energy Policy Act of 2005, Pub. L. No. 109-58, 2005 U.S.C.C.A.N. § 17, (119 Stat.) 596.

largely vindicated the safety of hydraulic fracturing.¹¹⁶ Thus, at present, it seems unlikely that the federal government will regulate hydraulic fracturing to the point where unconventional development will significantly slow down or cease.

The same cannot be said for Europe, where the threat of regulation could significantly deter investment, at least in the short run. Unlike the United States, where federal regulation of hydraulic fracturing—apart from regulating the practice on public lands—seems unlikely, the European Union may enact federal regulations.¹¹⁷ A recent report found no immediate need for federal regulation, citing adequacy of national regulation; however, the report left open the possibility of federal regulation once shale gas becomes commercial.¹¹⁸ This wait-and-see approach may not reassure shale-gas investors that the European Union will refrain from enacting crippling regulations in the future.

The impetus for such regulation could come from the United States. Perhaps all it will take is one major hydraulic-fracturing accident in the United States. Over one million wells have been hydraulically fractured in the United States¹¹⁹ without a major incident, but that does not guarantee an incident-free future.

F. Market Pricing

Wellhead natural gas was completely deregulated in the United States in 1989.¹²⁰ Pipeline companies that had exercised monopsony and monopoly power in the purchase and resale of gas ceased to be regulated gas merchants and became regulated transporters.¹²¹ Deregulation encouraged unconventional exploration and development until the market price collapsed in 2008.¹²² Now gas prices are too low to sustain shale-gas drilling unless the reservoirs contain significant amounts of natural gas liquids.¹²³ This is unfortunate because shale-gas wells have a steep

¹¹⁶ Jeffrey C. King, Jamie Lavergne Bryan, & Meredith Clark, *Factual Causation: The Missing Link in Hydraulic Fracture-Groundwater Contamination Litig.*, 22 Duke Envt'l L. & Pol'y F. 341, 352-58 (2012).

¹¹⁷ Marko Bucik, *The case for EU-level legislation of hydraulic fracturing*, http://www.academia.edu/2389804/The_case_for_EU-level_legislation_of_hydraulic_fracturing

¹¹⁸ *Final Report on Unconventional Gas in Europe*, PHILIPPE & PARTNERS § 9.2 (November 8, 2011), http://ec.europa.eu/energy/studies/doc/2012_unconventional_gas_in_europe.pdf.

¹¹⁹ King, George E (2012), Hydraulic fracturing 101 (PDF), Society of Petroleum Engineers, Paper 152596.

¹²⁰ The passage of the Natural Gas Wellhead Decontrol Act in 1989 officially completed the process of wellhead price deregulation. *A Brief History of Natural Gas*, Am. PUBLIC GAS ASSOC., <http://www.apga.org/i4a/pages/index.cfm?pageid=3329> (last visited Sept. 7, 2013).

¹²¹ “Under the current regulatory environment, only pipelines and local distribution companies (LDCs) are directly regulated with respect to the services they provide. Natural gas producers and marketers are not directly regulated.” *The Mkt. Under Regulation*, <http://www.naturalgas.org/regulation/market.asp>

¹²² U.S. natural gas wellhead prices dropped from \$7.97 per Mcf in 2008 to \$3.67 in 2009. *U.S. Natural Gas Wellhead Prices*, EIA, <http://www.eia.gov/dnav/ng/hist/n9190us3a.htm> (last visited Sept. 7, 2013).

¹²³ U.S. natural gas wellhead prices dropped even lower to \$2.66 per Mcf in 2012. *Id.*

decline rate. Professor Steven Holditch has noted that “decline rates are high early in the life a [shale-gas] well (rates of 70 percent per year or more have been observed in the first year of production)... [But] [t]he decline rate becomes smaller over time.”¹²⁴ Therefore, wells must be continuously drilled to sustain a constant level of production. Lower prices discourage drilling, which in turn risks possible tight gas supplies in the event that prices rebound due to a cold winter, rapid economic recovery, or both.

While Europe has taken steps to deregulate gas, it has done so largely in the last 15 years, with some countries, such as Poland, just starting to seriously implement deregulation in 2013.¹²⁵ Even with deregulation, Europe’s transition from strict regulation to marketization of natural gas prices has not been without obstacles.

Corruption is a potential problem that could hurt European shale-gas development. For example, in January of 2012, ABW, a Polish internal security agency, detained seven people “suspected of bribery related to the granting of shale-gas exploration licenses.”¹²⁶ Three detainees were Environment Ministry officials and one was from the Polish Geological Institute.¹²⁷ Corruption of this magnitude has the potential to impede investment by companies subject to anti-bribery statutes, such as the Foreign Corrupt Practice Act in the United States and the Bribery Act of 2010 in the United Kingdom.

Despite industry concerns about corruption, today’s European market price of gas is encouraging shale-gas exploration. In 2013, Statoil, Europe’s second largest supplier, moved away from oil-linked gas pricing to spot prices at hubs, such as the National Balancing Point in the United Kingdom.¹²⁸ Gazprom, a Russian based company, has been forced into similar pricing, but it prefers oil-linked pricing with rebates to spot pricing.¹²⁹ In the short term, according to analysts at Wood McKenzie, gas prices might go up under this new pricing system, not down.¹³⁰ However, if oil prices fall, then Russian gas prices, which continue to be linked mostly to oil prices, will fall and Russia will gain market share.¹³¹ Volatile, but especially lower gas prices in Europe, could dampen enthusiasm for shale gas.

¹²⁴ Steven A. Holditch, *Getting the Gas Out of the Ground*, AM. INST. OF CHEMICAL ENGINEERS 41, 46 (Aug. 2012), <http://energy.tamu.edu/media/90710/holditch%20-%20hydraulic%20fracturing.pdf>.

¹²⁵ During the summer of 2013, Poland began its transition to market controlled gas prices. Previously, gas was supplied by the state controlled utility PGNiG. Marynia Kruk, *Polish Gas Utility Braces for Deregulation*, THE WALL STREET JOURNAL (Mar. 15, 2013), <http://blogs.wsj.com/emergingurope/2013/03/15/polish-gas-utility-braces-for-deregulation/>.

¹²⁶ *Poland detains 7 suspected of shale gas corruption*, REUTERS (Jan. 10, 2012), available at <http://www.reuters.com/article/2012/01/10/poland-shale-idUSL6E8CA5Q020120110>.

¹²⁷ *Id.*

¹²⁸ Henning Gloystein & Nerijus Adomaitis, *Analysis: Statoil to gain in Europe's shift to spot gas pricing*, REUTERS (Aug. 14, 2013), available at <http://www.reuters.com/article/2013/08/14/us-energy-gas-oil-analysis-idUSBRE97D0GR20130814>.

¹²⁹ *Id.*

¹³⁰ *Id.*

¹³¹ *Id.*

However, if Europe wants to lessen its dependency on Russian gas, then it may need to take steps to protect its shale-gas industry from sharp price declines.

G. Petroleum-Friendly Tax Environment

The United States federal income tax laws provide three benefits to the oil and gas industry to spur drilling. For purposes of shale-gas drilling, the most important is the intangible drilling and completion costs (IDC) deduction, which can generally range from 60-80 percent of total well costs.¹³² Oil and gas companies can elect to either capitalize IDCs over 60 months or deduct them in the year incurred.¹³³ In general, if a company has income against which it may offset IDCs, it will elect to deduct them.¹³⁴ Undoubtedly, the IDC deduction helped George Mitchell when he was trying to perfect horizontal drilling and hydraulic fracturing in shale.

Thanks to the so-called “pool of capital” doctrine, companies can also enter into joint ventures without having to form a partnership or corporation in order to avoid a taxable event.¹³⁵ Under this doctrine, Company X and Company Y might enter into a farmout agreement, whereby Company X contributes the well site and Company Y contributes the drilling costs. Because this is regarded as the pooling of capital, the transaction is not considered taxable. Without this doctrine, the transfer of ownership would constitute a taxable event, thus increasing the costs of entering into a joint venture.

Finally, “independent” companies may qualify for percentage depletion. Under percentage depletion, up to 15 percent of production income can be tax free. The percentage depletion allowance is not tied to tax basis and is available for the life of a well’s production.¹³⁶

¹³² *Intangible Drilling Costs: Crucial Underpinning of Affordable US Energy Supply*, AM. EXPLORATION & PROD. COUNCIL (Sep. 2012), http://www.axpc.us/download/issues_and_info/public%20policy/public_policy_sep2012.pdf.

¹³³ *Global oil and tax guide 2013*, ERNST AND YOUNG, 583 (Jun. 2013), [http://www.ey.com/Publication/vwLUAssets/2013_global_oil_and_gas_tax_guide/\\$FILE/EY_Oil_and_Gas_2013.pdf](http://www.ey.com/Publication/vwLUAssets/2013_global_oil_and_gas_tax_guide/$FILE/EY_Oil_and_Gas_2013.pdf).

¹³⁴ *Id.*

¹³⁵

If structured properly, these arrangements can be entered into with little or no current income tax implications under the “pool of capital” doctrine. The arrangements must be structured so that the investment made by both parties relates to the same oil and gas property or properties. For example, assume Taxpayer X, owner of the mineral interest, structures an arrangement whereby Company A agrees to drill and pay all the costs for the first well on a tract. If Company A receives an interest in the same property as its only consideration, the arrangement should be accorded non-taxable treatment for both parties.

Global oil and tax guide 2013, Ernst and Young, *supra* note 1299, at 588.

¹³⁶

Independent producers and royalty owners who own US domestic property are allowed percentage depletion based on the statutory rates and limitations. For oil and gas production, the statutory rate is 15 percent of gross income, limited to 100 percent of the net income of the property, determined on a property-by-property basis. Percentage depletion is further limited to 1,000 barrels of production a day.

Although corporate tax rates are typically lower in Europe, tougher fiscal terms or special hydrocarbon taxes, or both, generally make Europe a high-cost continent for oil and gas development. In addition, a few European countries require companies to ring fence each field or block for tax purposes—generally meaning that expenses from one field or block may not be offset against income from another field or block.¹³⁷ Some adjustment in European fiscal terms and taxes would seem to be necessary to attract large-scale shale-gas exploration and development.¹³⁸

The most significant tax benefit for a range of unconventional fuels was the Section 29 tax credits, effective from 1980 to 2002.¹³⁹ Section 29 credits contributed to more than doubling unconventional gas production during this time frame, much of it was coalbed methane production.¹⁴⁰

H. Less Densely Populated

With the exception of the Barnett Shale in Texas, the shale plays in the mid-continent region of the United States are occurring in rural areas that are characterized by large farms and ranches, especially compared to Europe. And while drilling in the Barnett has been controversial, Texans are accustomed to oil and gas activity. Nevertheless, voters in Denton, Texas, a suburb of Dallas-Fort Worth, voted to ban hydraulic fracturing within city limits. Problems have also arisen in Weld County, Colorado, but here the problem is partly due to urban areas expanding into areas with active oil and gas plays.¹⁴¹ This urbanization has led Colorado to enact

Percentage depletion is prorated to the eligible property based on the ratio of 1,000 barrels to the total average daily production volume. The limited percentage depletion is compared with the cost depletion on a property-by-property basis. The taxpayer is allowed a deduction equal to the higher of the cost or percentage depletion on a property-by-property basis. Lastly, the taxpayer is subject to an overall taxable income limitation such that percentage depletion cannot exceed 65 percent of the taxpayer's taxable income (with certain adjustments). Any depletion limited by the 65 percent limitation can be carried forward to future years without expiration. The actual depletion deducted in the current-year return is the amount that reduces the leasehold basis for the year.

Global oil and tax guide 2013, Ernst and Young, *supra* note 1299, at 582-83.

¹³⁷ *Id.* at 161 (discussing Denmark); *Id.* at 240 (discussing Ireland).

¹³⁸ For a summary of what Poland has done, *see generally* *id.*, 430-31.

¹³⁹ Jason Burwen & Jane Flegal, *Case Study: Unconventional Gas Production (2013)*, AMERICAN ENERGY INNOVATION COUNCIL, <http://americanenergyinnovation.org/staff-research/case-study-unconventional-gas-production-2013/>.

¹⁴⁰ *Testimony Before the Subcommittee on Select Revenue Measures: Hearing on the Effect of Federal Tax Laws on the Production, Supply and Conservation of Energy*, 107th Cong. (2001) (statement by Steven R. Williams, President, Petroleum Development Corporation), available at <http://waysandmeans.house.gov/legacy/srm/107cong/5-3-01/5-3-will.htm>

¹⁴¹ There are over 16,500 active oil and gas wells in Weld County, more than any other county in the state. *Part I: A Boom is Born*, COLORADO OIL & GAS ASS'N, <http://www.coga.org/index.php/Mission#sthash.0V8Lhts4.dpbs> (last visited Sept. 6, 2013). In 2012, Weld County's population grew to 260,000. *State & County QuickFacts*, U.S. CENSUS BUREAU, <http://quickfacts.census.gov/qfd/states/08/08123.html> (last visited Sept. 6, 2013).

stricter well-location regulations¹⁴² and more monitoring of freshwater supplies in areas where hydraulic fracturing is occurring.¹⁴³ Voters in Fort Collins, Lafayette, and Fort Collins have enacted fracking bans.¹⁴⁴

The following oil and gas producing states are among the 15 least densely populated states in the United States:¹⁴⁵ Alaska, .46 people/km²; Wyoming, 2.12 people/km²; Montana, 2.57 people/km²; North Dakota, 3.59 people/km²; South Dakota, 4.09 people/km²; New Mexico, 3.59 people/km²; Nebraska, 9.14 people/km²; Utah, 12.86 people/km²; Kansas, 13.22 people/km²; Colorado, 18.39 people/km²; and Oklahoma, 18.39 people/km². For many of these states, population-density numbers are deceiving because, for the most part, oil and gas development is occurring in areas where the density is actually much less. For example, the Bakken play in North Dakota is mostly occurring in an area of the state where population density is less than 1 person/km².¹⁴⁶

In contrast, in Poland, where shale-gas exploration is occurring, population density is 123 people/km².¹⁴⁷ The United Kingdom, where shale-gas exploration is supported by the Cameron administration, has a population density of 256 people/km².¹⁴⁸ In France and Bulgaria, where hydraulic fracturing is currently banned, the population density is, respectively, 117 people/km² and 66

¹⁴² Effective August 1, 2013:

[N]ew oil and gas operations generally cannot be constructed within 500 feet from residential buildings and certain commercial and warehouse facilities. If new oil and gas operations are located within 1,000 feet of these buildings, the regulation requires stringent mandatory mitigation measures to minimize the effects of the drilling. The new regulation also prohibits oil and gas operations within 1,000 feet of specific high occupancy buildings, including schools, day care centers, hospitals, nursing homes and correctional facilities, without commission approval following a public hearing. Finally, the rule requires notification of the owners of certain property located near oil and gas operations and will increase the opportunities for local government to review and comment on proposed oil and gas locations.

Colin C. Deihl & Ann E. Prouty, *Oil & Gas Regulation in Colorado: Devs. During the 2013 Legislative Session*, FAEGRE BAKER DANIELS (Jun. 3, 2013), <http://www.faegrebd.com/20032>.

¹⁴³ Proposed groundwater sampling rules (House Bill 1316) died in the senate in 2013. <http://www.faegrebd.com/20032>.

¹⁴⁴ Keith Coffman, *Colorado an energy battleground as towns ban fracking*, REUTERS (Nov 6, 2013), available at <http://www.reuters.com/article/2013/11/06/us-usa-fracking-colorado-idUSBRE9A50QT20131106> (last viewed on December 3, 2014).

¹⁴⁵ U.S., WORLD ATLAS, <http://www.worldatlas.com/aatlas/populations/usadensityh.htm> (last visited Sept. 4, 2013).

¹⁴⁶ Based upon converting United States Census Bureau data of density per square mile to density per square kilometer, where 1.0 square mile equals 2.59 square kilometers for McKenzie County, North Dakota, located in the heart of the Bakken play. Population density in McKenzie county in 2010 was 2.3 persons per square mile. *State & County QuickFacts*, U.S. CENSUS BUREAU, <http://quickfacts.census.gov/qfd/states/38/38053.html> (last visited Jan. 8, 2015).

¹⁴⁷ Smith, *supra* note 819, at 284.

¹⁴⁸ *Id.* at 286.

people/km².¹⁴⁹ In general, one would logically expect that the more densely populated an area, the more opposition to oil and gas drilling.

Modern well pads for multiple horizontal wells occupy only about 1.6 hectares or about 2.9 hectares, counting access roads and utility corridors.¹⁵⁰ From a single pad, multiple horizontal wellbores can be drilled, taking the place of 16 vertical well sites, depending upon drilling-unit size.¹⁵¹ North Dakota has recently considered the authorization of drilling units of up to 5,120 acres (2,072 hectares),¹⁵² with the result that one drill pad can replace the equivalent of 128 or more vertical well sites—an amazing reduction in the drilling footprint. Nevertheless, for densely populated areas unaccustomed to oil and gas drilling, this is likely to be unconvincing to landowners and occupants, especially when one considers that the direct financial beneficiary of development is the government, not the local population, due to government ownership of the oil and gas resources.

I. Private (not Public) Ownership

Although the federal government funded research into shale oil and shale gas and participated in initial demonstration projects, shale oil and shale gas were largely commercialized on private lands.¹⁵³ Private ownership of mineral rights has served to quicken the pace of shale plays. While locating and acquiring leases from what oftentimes are hundreds of owners of small tracts, small fractional mineral interests, or both, are time consuming and expensive, oil and gas leases can ordinarily be acquired quite easily once the owners are identified. Many mineral owners are happy to take the oil company's first offer. Indeed, the current owners of mineral rights were severed from surface ownership decades earlier, having inherited them over several generations, may not realize that they own mineral rights until they receive an offer to lease them. Thus, signing bonuses are often quite low and fiscal terms are often quite favorable to the company lessee. If a company cannot locate an owner or cannot secure a lease on acceptable terms from owners that have been located, then, in most states, the company is aided by compulsory pooling laws that allow the

¹⁴⁹ *Id.* at 286-87.

¹⁵⁰ Based upon converting acres to hectares, where one acre equals 0.40 hectares. Dan Arthur & Dave Cornue, *Techs. Reduce Pad Size, Waste*, THE AM. OIL & GAS REPORTER (Aug. 2010), available at <http://www.all-llc.com/publicdownloads/AOGR-0810ALLConsulting.pdf>.

¹⁵¹ Erik Bauss, *Modern Well Dev. Tech. Produces Big Time Envtl. Benefits for Mich.*, ENERGY IN DEPTH (Oct. 24, 2012, 5:05 PM), <http://energyindepth.org/michigan/modern-well-development-technology-produces-big-time-environmental-benefits-for-michigan/>.

¹⁵² North Dakota Industrial Comm'n, Order 24702 (November 21, 2014).

¹⁵³ In some states in the Western United States, the federal government does own large amounts of land, but shale gas and shale-oil development has largely occurred in areas where there is little or no federal land. While states may hold title to significant acreage, most of those acres came in the form of federal land grants to support schools, institutions, and other public improvements. Under the terms of these grants, the states were obliged to manage the lands to maximize income. Texas has significant state lands, but the Texas General Land Office is generally quite willing to lease its mineral holdings to oil companies, albeit for comparatively tougher fiscal terms.

lessee to secure development rights through a fast and relatively efficient administrative process.¹⁵⁴

Moreover, most mineral owners, at least owners of severed interests, are not typically concerned about the lessee's surface use or about the environmental impacts of oil and gas development. So long as development occurs in sparsely populated rural areas, the lessee is commonly not appreciably hindered or delayed by local land-use regulations.

On the other hand, surface owners who own no mineral rights, usually as a result of a prior severance of the mineral rights from the surface by a prior owner, may oppose oil and gas development—especially if the company intends to use their surface for a well location. Thus, some surface owners may become allies of environmental groups opposed to development. To counter this opposition, oil and gas developers generally compensate the surface owner for the use of the surface—often at a rate that exceeds the market value of the land used. Moreover, statutory laws in an increasing number of states require the oil and gas developer to compensate surface owners.¹⁵⁵

In addition to being compensated for the well site and access road, surface owners enjoy substantial leverage over developers for certain types of uses. The lessee of a severed mineral owner's acreage succeeds to the right of that owner to make reasonable and necessary use of the surface—a right that is implied or expressed in the instrument that severed the minerals from the surface. However, if implicit or if expressed in the usual terms, this right does not include use of the surface to exploit nearby lands that are not included in the drilling unit for that particular well.¹⁵⁶ Thus, if a lessee wants to build a gas gathering line connecting a large number of wells, the lessee will need to negotiate an easement to carry commingled gas through the land of each affected surface owner. Surface owners may drive a very hard bargain for such rights. Indeed, so-called “surface owner extortion” is partly blamed for the gas flaring that occurs in the Bakken shale oil play in North Dakota.¹⁵⁷

¹⁵⁴ N. DAK. CENTURY CODE § 38-08-08; MONT. CODE ANN. § 82-11-202 (2011), which grants Montana's Board of Oil and Gas Conservation “authority to force pool separately owned mineral tracts within an established well spacing unit even where all mineral owners do not consent, as in cases where mineral owners cannot be located.” Amy Mowry, *Troubleshooting Uncertain mineral Ownership in Mont.*, 28 Rocky Mountain Landman 1 (Jan. 2011).

¹⁵⁵ North Dakota Surface Owner Protection Act, N. DAK. CENTURY CODE Ch. 38-11.1 and Oklahoma Surface Damages Act, OKLA. STAT. tit. 52, §§ 318.2-318.9.

¹⁵⁶ In most states, if a developer secures compulsory pooling of a drilling and spacing unit (i.e., the area attributed to a well), then the developer can make reasonable use of any part of the surface area of the pooled unit for the purpose of exploiting any oil and gas beneath that unit.

¹⁵⁷ Approximately 1/3 of the natural gas produced in the North Dakota region of the Bakken is flared, equating to more than \$100 million per month. Hilton Price, *Bakken shale natural gas flaring tops \$100 million each month*, PENNENERGY (July 30, 2013), <http://www.pennenergy.com/articles/pennenergy/2013/07/bakken-shale-natural-gas-flaring-tops-100-million-each-month.html>. The North Dakota Industrial Commission, which regulates oil and gas conservation, has issued an order designed to restrict flaring in the Bakken play. N.D. Indus. Comm'n, Order 24665 (Jul. 1, 2014).

Other surface owners may be able to sell sand, gravel, scoria, or other road and well-site materials to developers. Still others or their spouses or children may be employed by the oil and gas developers. Thus, surface owners may become dependent on the oil and gas industry for their livelihood even if they own no oil and gas rights. Nevertheless, diehard opponents of oil and gas development, often surface owners without mineral rights, will ally themselves with environmental organizations to fight development. This opposition is more likely to occur in areas where population density is high or oil and gas development is recent, or both.

When oil and gas development occurs on private lands, federal, state, and local governments are largely left to “react” to the development through regulation. Even if comprehensive regulatory laws pre-date a particular play, governments play a reactive role in enforcing the regulations. Short of the draconian tactic of a government-mandated ban, such as occurred in New York regarding shale-gas development, governments have no ability to halt development. Indeed, political pressures may prompt the government to speed development to spur the economy or to collect production taxes. The need to spur the economy may have played a role in the shale-gas development in Ohio and Pennsylvania, states hit hard by the economic downturn that started in 2008.

III. CONCLUSION

The IEA has suggested that the world may be entering a Golden Age of Gas.¹⁵⁸ The question is whether Europe will be part of this Golden Age or will remain a major importer. If it remains a major importer, it will continue to suffer the political insecurity of Russian gas, the more costly reliance on LNG, or both. However, assuming Europe does move forward in shale-gas production, it will do so in an evolutionary, not revolutionary, way.

In addition to Poland, which has yet to establish economically recoverable reserves of shale gas, the United Kingdom appears to be moving the most aggressively toward exploiting shale gas.¹⁵⁹ Perhaps this transition was caused by new findings by the British Geological Survey estimating central Britain reserves at 1,300 trillion cubic feet of shale gas,¹⁶⁰ and the fact that UK gas production has dropped about 40 percent in a decade.¹⁶¹ “While the country imports gas to make up the shortfall, some of that gap is now being met by coal.”¹⁶² Prime Minister David Cameron wrote in the DAILY TELEGRAPH about why he supports UK shale-gas

¹⁵⁸ See *Are We Entering a Golden Age of Gas*, INT’L ENERGY AGENCY (IEA) (2011), http://www.worldenergyoutlook.org/media/weowebiste/2011/WEO2011_GoldenAgeofGasReport.pdf; see also, *Golden Rules for a Golden Age of Gas*, IEA (May 29, 2012), <http://www.worldenergyoutlook.org/goldenrules/>.

¹⁵⁹ According to one authority, the UK began fracking in the 1970’s and has performed over 200 onshore fracs. Eric Vaughan, Well Services Dir., Caudrilla, Presentation at Shale Gas World: Hydraulic Fracturing in the UK (June 26, 2013).

¹⁶⁰ *New shale gas resource figure for central Britain*, BRITISH GEOLOGICAL SOC’Y, <http://www.bgs.ac.uk/shalegas/#ad-image-0> (last visited Sep. 7, 2013).

¹⁶¹ Helen Robertson, *Have you got a fracking clue?*, PETROLEUM ECONOMIST (Aug. 19, 2013), available at <http://www.petroleum-economist.com/Article/3245011/Have-you-got-a-fracking-clue.html#ixzz2coRRxiO4>.

¹⁶² Indeed, “[l]ast year the UK used 30 percent less gas-fired power than the year before and is instead using coal to offset this loss because it’s cheaper.” *Id.*

development and associated hydraulic fracturing. He stated that hydraulic fracturing will “drive energy bills down,...make our country more competitive,...create jobs, ... [and] bring money to local neighborhoods.”¹⁶³ To encourage support by affected local communities, Cameron noted that the oil and gas companies had agreed to pay £100,000 to every community situated near an exploratory well plus 1 percent of the revenue of any productive well.¹⁶⁴ The question is whether the Cameron administration will survive harsh opposition by environmental organizations so that the United Kingdom’s shale-gas reserves will actually be developed.

¹⁶³ David Cameron, *We cannot afford to miss out on shale gas*, THE TELEGRAPH (Aug. 11, 2013), available at <http://www.telegraph.co.uk/news/politics/10236664/We-cannot-afford-to-miss-out-on-shale-gas.html>.

¹⁶⁴ *Id.*