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Shale Gas Revolution or Evolution: Opportunities and Challenges for Europe [reprint, first published 2013]

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VOLUME 3

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SHALE GAS REVOLUTION OR EVOLUTION: OPPORTUNITIES AND CHALLENGES FOR EUROPE* [reprint, first published 2013]

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I. Shale Gas—More Evolution Than Revolution.....	106
II. Why Will European Shale Gas Evolve More Slowly Than in the United States?	116
A. Risk-Taking Independents	116
B. Larger and More Experienced Petroleum Services Industry	118
C. More Robust Infrastructure.....	120
D. Less Radical Environmental Community	121
E. Less Regulation.....	123
F. Market Pricing.....	124
G. Petroleum-Friendly Tax Environment.....	126
H. Less Densely Populated.....	128
I. Private (not Public) Ownership.....	130
III. Conclusion	132

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Shale gas was first developed in significant quantities in the United States. In 2000, shale gas accounted for a mere 1% of total US gas production.¹ In 2010 shale gas accounted for 20% of US gas production, and by 2035 could account for 46%.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%.³

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 United Kingdom has ended its moratorium on shale gas development after concluding that the risk of earthquakes is low and can be mitigated. 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 also requires sufficiently high gas prices.

On the other hand, France still has in place a moratorium on shale gas. Poland is allowing shale gas exploration, but Poland's geology is proving to be more difficult than expected. Although, exploration is proceeding, some companies have pulled 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

1. Paul Stevens, *The ‘Shale Gas Revolution’: Developments and Changes*, CHATHAM HOUSE, (Aug. 2012), http://www.chathamhouse.org/sites/default/files/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 *SHALES IN EUROPE* 9, 10 (Cecile 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 Administration (EIA), <http://www.eia.gov/analysis/studies/worldshalegas/> (last updated June 13, 2013).

4. This estimate is 10% 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*, http://www.dec.ny.gov/docs/materials_minerals_pdf/nyserda2.pdf (last visited Aug. 29, 2013).

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 gas, it is the manner in which it was 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. Even super majors were slow to invest in shale plays. For example, ExxonMobil first entered the shale gas play in 2009 by acquiring XTO Energy, effective June 25, 2010.⁹ Shell 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 Efforts to recover gas from shale began in earnest in 1976, when President Gerald Ford advocated funding research into unconventional gas development.¹² In the 1970s, several shale gas experimental wells were drilled with federal participation.¹³ In 1980, the Energy Act provided “Section 29” tax credits for unconventional gas

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.

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

12. 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.

13. *Id.*

development.¹⁴ 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.¹⁵ The Energy Research and Development Administration funded the Morgantown Energy Research Center,¹⁶ which did pioneering research in association with nine national laboratories and private industry to demonstrate and improve shale fracturing and horizontal drilling technologies.¹⁷ The results of these research efforts were shared with the oil and gas industry. In 1986, the Department of Energy and several private companies air drilled a demonstration well into shale in West Virginia and hydraulically fractured it.¹⁸

In 1991, the Gas Research Institute subsidized Mitchell Energy's first successful horizontal well in the Texas Barnett Shale.¹⁹ The late George Mitchell, son of a Greek immigrant who ran a dry cleaning business, is considered the father of hydraulic fracturing.²⁰ Mitchell graduated first in his class from Texas A&M University in 1940 with a degree in petrochemical engineering and geology.²¹ During his lifetime he participated in drilling about 10,000 wells, including over 1,000 wildcat wells.²² 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.²³ "There's no point in mincing words. Some people thought it was stupid," including "probably

14. 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.*

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

16. Later developed into the National Energy Technology Laboratory.

17. 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.

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

19. *Id.*

20. *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].

21. *Id.*

22. *Id.*

23. *Id.*

90 percent of the people” in the firm.²⁴ Mitchell’s company didn’t even cover the cost of fracking on shale tests until the 36th well was drilled.²⁵ Mitchell’s first economically viable shale gas well in the Barnett Shale was drilled in 1998.²⁶ 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.²⁷

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.²⁸ Shale gas meets these criteria because it is locked in

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

25. *Id.*

26. *Testimony of Jesse D. Jenkins, supra* note 18, Figure 6, at 23.

27. George P. Mitchell, *supra* note 20.

28. “‘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*, 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 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.

Search Results - Schlumberger Oilfield Glossary, SCHLUMBERGER, <http://www.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.

comparatively impermeable rock, which complicates recovery.²⁹ 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.³⁰ Thus, drill cuttings of many shales reveal the presence of oil, gas, or both, but until recently shale gas and oil have not been technically and economically recoverable in sufficient volumes.³¹

Two technical innovations have allowed the recovery of oil and gas from shale: horizontal drilling and hydraulic fracturing.³² A third, 3D seismic, has also played a role.³³

Although the intentional drilling of directional or slant production wells occurred as early as the 1920s and were drilled in the 1930s to fight oilfield fires, 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 up to the surface as drilling proceeded.³⁴ Horizontal

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* 128 (2011), http://www.spe.org/industry/docs/PRMS_Guidelines_Nov2011.pdf.

29. Trembath et al., *supra* note 8.

30. Hydrocarbon reservoirs are not found in shale because its permeability is a million times lower than “conventional reservoir rock.” Jose Martinez de Hoz, Tomas Lanardonne & Alex Maculus, *Shale we Dance an Unconventional Tango?*, 6 J. OF WORLD ENERGY BUS. 179, 180 (2013).

31. “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.

32. Stevens, *supra* note 1, at 2; *New Energy Future*, *supra* note 28, at 2.

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

34. “[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 (1993), http://www.eia.gov/pub/oil_gas/natural_gas/analy

drilling was used extensively in the development of the Austin Chalk oil play in south central Texas in the 1980s and 1990s.³⁵ The Austin Chalk formation contained narrow, vertical columns of oil bearing rock.³⁶ A vertical well may or may not have encountered these lenses, but a horizontal lateral borehole could encounter multiple lenses.³⁷ More recent rotary steering system tools allow more accurate directional control of the drilling bit.³⁸ Today, through the use of rotary steering systems, horizontal laterals can be steered quite precisely to expose particular portions of a target formation.³⁹

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, “frac fluids,” are injected into a wellbore under very high pressure.⁴⁰ The frac fluids are forced by the hydraulic pressure into the targeted formation to crack or fracture it, thereby artificially enhancing permeability—facilitating the ability of fluids to flow through the reservoir rock.⁴¹ Sand, ceramic beads, or other “proppants” are also injected into the fractures.⁴² When the injected fluid is withdrawn, the proppants remain to hold the cracks or fractures open to facilitate the flow of hydrocarbons into

sis_publications/drilling_sideways_well_technology/pdf/tr0565.pdf [hereinafter Drilling Sideways].

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

36. “The formation is a massive, oilbearing limestone that, in some locations, is extensively vertically fractured.” *Id.* at 13.

37. “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.*

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

39. 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 34, at 14.

40. “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% 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://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf [hereinafter Shale Gas Primer].

41. *Id.*

42. *Id.* at 61.

the wellbore. Thus, hydraulic fracturing is classified as a form of well completion. Once the hydraulic fracturing operation is finished, the frac equipment is removed from the well site and hydrocarbon production ensues. Hydraulic fracturing was first used in 1947 to extract natural gas from limestone⁴³ and was commercially used by 1949 to complete vertical wells.⁴⁴ Today, over 60% of the wells drilled in the United States are hydraulically fractured.⁴⁵

Together, horizontal drilling serves to expose more reservoir rock to the well bore, and hydraulically fracturing 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 to World War I, when measuring the speed of sound through the air was used to locate the positions of enemy artillery.⁴⁶ It was adapted for use in oil and gas exploration in Oklahoma in the 1920s.⁴⁷ 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 only gathered along a narrow line of subsurface. This basic geophysical exploration is generally called conventional or sometime 2-D seismic. Today, thanks to the 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 probably presence of

43. Trembath et al., *supra* note 8.

44. In 1949, after obtaining a patent and an exclusive license to pump the new Hydrafrac process, 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%. Carl T. Montgomery and Michael B. Smith, *Hydraulic Fracturing, History of Enduring Tech.*, JOURNAL OF PETROLEUM TECH., 27 (2010), <http://www.spe.org/jpt/print/archives/2010/12/10Hydraulic.pdf>.

45. *Id.*

46. 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).

47. 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.

hydrocarbons.⁴⁸ Today, additional seismic data can be gathered through a monitor well bore that can 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 recovery⁴⁹.

Unfortunately, shale gas has become the victim of its own success.⁵⁰ Increased domestic gas production, coupled with economic recession that began in 2008, has caused gas prices to plummet from over \$13 per million British Thermal Units (mmBTU) to less than \$2.50 in 2012.⁵¹ When this article was written in July of 2013, natural gas was priced at about \$3.60 per mmBTU.⁵² This price decline has resulted in less enthusiasm for more costly renewable forms of energy and caused drilling to shift to shale oil formations and to shale gas formations that are rich in natural gas liquids (NGLs).⁵³ Construction of LNG regasification facilities in the United States have been put on hold in favor of LNG liquefaction facilities to allow the

48. 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>.

49. 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*, <http://innovate.statoil.com/StatoilTechnologyInvest/Documents/Sensor%20Developments.pdf> (last visited Aug. 26, 2013).

50. “[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.

51. *Id.*

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

53. “[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 50.

export of natural gas to regions of the world where gas prices are much higher, such as Asia—especially Japan where LNG prices were about \$15.75 per mmBTU in September 2013.⁵⁴

In addition, some environmental groups strongly oppose hydraulic fracturing. Environmental activists have raised many objections. Of foremost concern is the potential that frac fluids or resulting gas production could contaminate freshwater. Given the depth of shale gas wells relative to freshwater supplies (there are typically thousands of feet of rock between the shale and fresh groundwater resources)⁵⁵ and modern well cementing and casing practices, these concerns are greatly exaggerated.⁵⁶ But it is possible that a failed cement job on a well or migration of frac fluids or gas into older improperly plugged wells could contaminate freshwater. To date, no such pollution has been proven.⁵⁷

Secondly, the disposal of frac fluids is controversial. Injection of fracturing fluids into over-pressurized disposal wells has been blamed for small earthquakes in Arkansas and in a few other locations. This concern is real in some locations.⁵⁸ Surface disposal of fracturing fluids is also controversial due to concerns that existing treatment facilities are unable to remove all pollutants.⁵⁹

Thirdly, the volume of freshwater used in hydraulic fracturing is controversial, especially in arid and semi-arid regions. Each well requires

54. *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).

55. Shale Gas Primer, *supra* note 40, at ES-4.

56. 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.zFLi8DwU.dpbs>.

57. 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>.

58. 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 40, at 25, 32.

59. 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.

several million gallons of water.⁶⁰ Although this amount per well is relatively small, when compared to other uses, this per-well amount taken times thousands of wells is significant.⁶¹ The answer is recycling and reuse and perhaps developing a means of fracturing that uses substantially less water.⁶²

Fourthly, the hydraulic-fracturing operation does cause additional air pollution, including the emission of greenhouse gases, while the operation is occurring.⁶³ The operation also increases noise.⁶⁴ 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 like wind and solar that emit no greenhouse gases.⁶⁵ 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.⁶⁶

All of the above concerns will have a greater impact in Europe than they have in the United States—a matter 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 you consider that shale gas took about 30 years to develop from an experimental demonstration to 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

60. *Id.*

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

62. 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 as oil. Ingrid Lobet, *Hold the water: Some firms fracking without it*, HOUSTON CHRONICLE (2013), <http://fuelfix.com/blog/2013/08/26/hold-the-water-some-firms-fracking-without-it/>.

63. 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 40, at ES-4.

64. 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.*

65. 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 57.

66. 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% 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).

rapidly in mid-2013. Poland is actively promoting shale gas but the geology is not cooperating. On the other hand, if you consider 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, then Europe is unlikely to have either experience. The reasons will be discussed in the ensuing section.

II. Why Will European Shale Gas Evolve More Slowly Than in the United States?

A. Risk-Taking Independents

This point was alluded to in the prior section, but the 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.⁶⁷ 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.⁶⁸ 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 2011.⁶⁹ ExxonMobil acquired XTO Energy, Inc. in 2009, maintaining it as a subsidiary.⁷⁰ 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,

67. 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.

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

69. *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).

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

Pennsylvania, and Texas.⁷¹ In 2011, ExxonMobil's CEO, Rex Tillerson, had to defend the decision to buy XTO before angry shareholders.⁷²

In 2011, BHP Billiton, the world's largest mining company, acquired Petrohawk Energy, along with its shale gas resources in Texas and Louisiana.⁷³ Earlier in 2011, BHP acquired Chesapeake Energy's Fayetteville shale gas assets, including a midstream pipeline.⁷⁴

And, 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 a profit with his 36th well.⁷⁵ 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.⁷⁶

While shale oil and shale gas have now been proven to work in several major basins in the United States,⁷⁷ the geology can be challenging. For example, challenging geology has been a problem in establishing profitable shale gas production in Poland.⁷⁸ In the United States, much shale

71. *Id.*

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

73. 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>.

74. *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>.

75. George P. Mitchell, *supra* note 20.

76. 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>.

77. For example, 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 Basin in Oklahoma and Texas, and the Bakken Shale Play in the Williston Basins, 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).

78. 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,

production occurs from relatively shallow formations⁷⁹ that have been drilled through by operators seeking deeper conventional production.⁸⁰ Geophysical data is also available for these areas. Thus, at least in some plays, such as those in Texas and North Dakota, much is already known about the geology.⁸¹

Moreover, in Europe, political risk is greater, largely due to a more influential environmental lobby,⁸² 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.⁸³ 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—although many exploration and production companies might take issue with the latter. By and large, labor unions are not much of a factor in the United States petroleum sector. Over the years, United States service companies have developed new and improved technologies to facilitate precise horizontal drilling and highly effective

“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 (Cecile Musialski et al. eds., 2013).

79. For example, the Barnett Shale in the Fort Worth Basin, Texas is found at depths ranging from 5,000-8,000 feet. *The Barnett Shale*, HALLIBURTON, http://www.halliburton.com/public/solutions/contents/Shale/related_docs/Barnett.pdf (last visited Sept. 3, 2013).

80. 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 drillcuttings, core samples, and other data about the Bakken because deep wells bores were drilled through the Bakken.

81. “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).

82. *Id.*

83. *Id.*

hydraulic fracturing.⁸⁴ 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.⁸⁵ Of these, about half are working in the United States, although not all are capable of drilling horizontally.⁸⁶ To develop shale plays, many more wells have to be drilled. For example, in the Bakken shale oil play, as many as 8 horizontal wells may be drilled on a 1,280-acre drilling unit, including monitoring wells. In the Bakken shale play alone, drilling could eventually total about 40,000 wells.⁸⁷ 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.⁸⁸

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 much of Europe. The North Sea has historically been one of the most expensive places to drill for oil and gas.⁸⁹ This is not solely due to the harsh environment. It is partially due to less competition in the well-services industry compared to the United States. Thus, profit margins

84. 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 78, at 284.

85. *Id.*

86. 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>.

87. This means the vast majority of wells in the Bakken have not yet been built—5,000 new wells by 2015 and 33,000 in the next 20 years alone are expected. Javier E. David, *Bakken Emerges as Contender for US Oil Drilling Crown*, CNBC (Mar. 23, 2013), <http://www.cnbc.com/id/100579131>.

88. For example, a decline in rigs from 210 on October 19, 2012 to 181 on November 30, 2012 caused a 2.2% 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), <http://www.bloomberg.com/news/2013-01-11/bakken-oil-output-fell-in-november-for-first-time-in-18-months.html>.

89. 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/.

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 is 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.⁹⁰ 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.⁹¹ While efforts are underway to curb flaring in the Bakken, it is hard to imagine that Europe would allow such waste of natural gas. Of course, European gas prices will better support installation of infrastructure, but this 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.

90. Every day, roughly 675,000 barrels of Bakken crude are 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), <http://www.jamestownsun.com/event/article/id/190394/>.

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

D. Less Radical Environmental Community

As a whole, the American population and hence its politicians are becoming less concerned with climate change.⁹² 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.⁹³ 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.⁹⁴ 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.⁹⁵ The Fund does favor 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 this practice.⁹⁶

The European environmental community will fight hydraulic fracturing with great zeal. Indeed, the community, by aligning with farmers, has barred hydraulic fracturing in France⁹⁷ and Bulgaria.⁹⁸ Moreover, the

92. 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, <http://sp.uconn.edu/~scruggs/gec11.pdf>.

93. *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/>.

94. 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>.

95. 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).

96. The EDF has been publicly criticized by roughly 70 environmental groups for its support of hydraulic fracturing. Lenny Bernstein, *Environmental Defense Fund Scolded by Other Green Organizations on ‘Fracking’*, WASH. POST (May 22, 2013), http://articles.washingtonpost.com/2013-05-22/national/39441658_1_oil-companies-energy-companies-kennedy-jr.

97. After mass protests by green groups across the country, French politicians voted 176151 in favor of banning fracking on July 1, 2011, becoming the first country declare it illegal. Tara Patel, *France Vote Outlaws ‘Fracking’ Shale for Natural Gas, Oil Extraction*,

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 frac fluid disposal operations.⁹⁹ Although experience in the United States has shown that these risks are low,¹⁰⁰ especially when compared to the total environmental footprint of coal, this will not stop the European environmental community from zealously trying to ban hydraulic fracturing. Indeed, groups like 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,¹⁰¹ a member of parliament, Caroline Lucas, a member of the Green Party, was arrested in August 2013 for blocking road access to a shale gas exploration site.¹⁰²

BLOOMBERG (July 1, 2011), <http://www.bloomberg.com/news/2011-07-01/france-vote-outlaws-fracking-shale-for-natural-gas-oil-extraction.html>.

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

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

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

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

102. Fiona Harvey & Peter Walker, *Caroline Lucas Among Dozens Arrested in Balcombe Anti-fracking Protest*, THE GUARDIAN (Aug. 19, 2013), <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.¹⁰³ 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.¹⁰⁴ Vermont, which has also banned hydraulic fracturing,¹⁰⁵ has no proven oil and gas reserves.¹⁰⁶ Maryland has a hold on applications to drill wells pending completion of a study on hydraulic fracturing,¹⁰⁷ but it too has no proven oil and gas reserves.¹⁰⁸

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.¹⁰⁹ Thus, state regulatory initiatives balance health, safety, and environmental concerns with economic factors. Nevertheless, no evidence suggests that states are "racing to the 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.¹¹⁰

The Federal Energy Policy Act of 2005 excluded hydraulic fracturing from federal jurisdiction under the Clean Water Act, Clean Air Act, and

103. 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>.

104. 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/natural-gas/crudeoilreserves/>.

105. *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).

106. U.S. Energy Information Admin., *supra* note 104.

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

108. U.S. Energy Information Admin., *supra* note 104.

109. 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/>.

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

Safe Drinking Water Act.¹¹¹ Moreover, although several studies are ongoing, scientific studies have largely vindicated the safety of hydraulic fracturing.¹¹² 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, part from regulating the practice on public lands, seems unlikely, the European Union may enact federal regulations.¹¹³ 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 become commercial.¹¹⁴ This wait-and-see approach may not reassure shale gas investors 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 a one major hydraulic-fracturing accident in the United States. Over one million wells have been hydraulically fractured in the United States¹¹⁵ without a major incident, but that does guarantee an incident-free future.

F. Market Pricing

Wellhead natural gas was completely deregulated in the United States in 1989.¹¹⁶ Pipeline companies that had exercised monopsony and monopoly power in the purchase and resale of gas ceased to be regulated gas

111. Public Law 109-58—AUG. 8, 2005, 119 STAT. 596 § 322, <http://www.gpo.gov/fdsys/pkg/PLAW-109publ58/pdf/PLAW-109publ58.pdf> (last visited Sept. 7, 2013).

112. Jeffrey C. King, Jamie Lavergne Bryan, & Meredith Clark, *Factual Causation: The Missing Link in Hydraulic Fracture-Groundwater Contamination Litig.*, 22 DUKE ENV'T L. & POL'Y F. 341, 352–58 (2012).

113. 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.

114. Final Report on Unconventional Gas in Europe, Philippe & Partners November 8, 2011, http://ec.europa.eu/energy/studies/doc/2012_unconventional_gas_in_europe.pdf, Section 9.2.

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

116. 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).

merchants and became regulated transporters.¹¹⁷ Deregulation encouraged unconventional exploration and development until the market price collapsed in 2008.¹¹⁸ Now gas prices are too low to sustain shale gas drilling unless the reservoirs contain significant amounts of natural gas liquids.¹¹⁹ This is unfortunate because shale gas wells have a steep decline rate. Professor Steven Holditch has noted that “decline rates are high early in the life a [shale gas] well (rates of 70% per year or more have been observed in the first year of production) . . . [But] [t]he decline rate becomes smaller over time.”¹²⁰ Thus, wells must be continuously drilled to sustain a constant level of production. Lower prices discourage drilling, risking possible tight gas supplies should prices suddenly rebound due to a cold winter or a 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 2013.¹²¹ 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.”¹²² Three detainees were Environment Ministry officials and one was from the Polish Geological Institute.¹²³ Corruption of this magnitude has the potential to impede the participation of companies subject to anti-bribery statutes, such as the

117. “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>.

118. 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).

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

120. 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>.

121. 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/>.

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

123. *Id.*

Foreign Corrupt Practice Act in the United States and the Bribery Act of 2010 in the United Kingdom.

Despite corruption hesitations, today's European market price of gas is encouraging shale gas exploration. In 2013, Statoil, Europe's second largest supplier, moved away of oil-linked gas pricing to spot prices at hubs, such as the National Balancing Point in the United Kingdom.¹²⁴ Gazprom, a Russian based company, has been forced into similar pricing, but it prefers oil-linked pricing and offering rebates to spot pricing.¹²⁵ In the short term, according to analysts at Wood McKenzie, gas prices might go up under this new pricing system, not down.¹²⁶ 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.¹²⁷ Volatile but especially lower gas prices in Europe could dampen enthusiasm for shale gas; however, if Europe wants to lessen its dependency on Russian gas, then it may need to take steps to avoid the effects of possible lower gas prices.

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. Oil and gas companies can elect to either capitalize IDCs over 60 months or deduct them in the year incurred.¹²⁸ In general, if a company has income against which it may offset IDCs, it will elect to deduct them.¹²⁹ IDCs generally range from 60-80% of total well costs.¹³⁰ Undoubtedly, the IDC deduction helped George Mitchell when he was trying to perfect horizontal drilling and hydraulic fracturing.

Thanks to the so-called "pool of capital" doctrine, companies can also enter into joint ventures without having to form a partnership or corporation

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

125. *Id.*

126. *Id.*

127. *Id.*

128. *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).

129. *Id.*

130. *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.

in order to avoid a taxable event.¹³¹ 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.

Finally, “independent” companies may qualify for percentage depletion. Under percentage depletion, up to 15% 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.¹³²

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 the 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.¹³³ Some

131.

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 128, at 588.

132.

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% of gross income, limited to 100% 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. 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% of the taxpayer’s taxable income (with certain adjustments). Any depletion limited by the 65% 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 128, at 582–83.

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

adjustment in fiscal terms and taxes would seem to be necessary to attract shale gas exploration and development.¹³⁴

The most significant tax benefit for a range of unconventional fuels was the Section 29 tax credits, effective from 1980 to 2002.¹³⁵ Section 29 credits contributed to more than doubling in unconventional gas production during this time frame.¹³⁶

H. Less Densely Populated

With the exception of the Barnett Shale in Texas, the shale plays in the midcontinent 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. 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.¹³⁷ This urbanization has led Colorado to enact stricter well-location regulations¹³⁸ almost resulted in

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

135. 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/>.

136. Steven R. Williams, Testimony Before the Subcommittee on Select Revenue Measures, US House of Representatives, May 3, 2001, <http://waysandmeans.house.gov/legacy/srm/107cong/5-3-01/5-3-will.htm>. Gas Technology Institute, Rationale for Section 29 Non-Conventional Gas Tax Credit Extension.

137. 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).

138. 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.

mandatory monitoring of freshwater supplies in areas where hydraulic fracturing is occurring.¹³⁹

The following oil and gas producing states are among the 15 least densely populated states in the United States:¹⁴⁰ 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/km².¹⁴¹

In contrast, Poland, where shale gas exploration is occurring population density is 123 people/km².¹⁴² The United Kingdom, where shale gas exploration is supported by the Cameron administration, has a population density of 256 people/km².¹⁴³ In France and Bulgaria, where hydraulic fracturing is currently banned, the population density is, respectively, 117 people/km² and 66 people/km².¹⁴⁴ 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.¹⁴⁵ From a single pad, eight to 16 or more horizontal wells can be

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>.

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

140. U.S., World Atlas, <http://www.worldatlas.com/aatlas/populations/usadensityh.htm> (last visited Sept. 4, 2013).

141. 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. Population, Housing Units, Area, and Density: 2010 - State -- County / County Equivalent, U.S. Census Bureau, http://factfinder2.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_SF1_GCTPH1.ST05&prodType=table (last visited Sept. 4, 2013).

142. Smith, *supra* note 74, at 284.

143. *Id.* at 286.

144. *Id.* at 286–87.

145. 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), <http://www.all-llc.com/publicdownloads/AOGR-0810ALLConsulting.pdf>.

drills, taking the place of 16 to 32 or more vertical well sites.¹⁴⁶ North Dakota has recently considered the authorization of drilling units of up to 5,120 acres (2,072 hectares), with the result that one drill pad can replace the equivalent of 128 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 was largely commercialized on private lands.¹⁴⁷ 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, some mineral owners, having inherited severed mineral rights through 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 lessee to secure development rights through a fast and relatively efficient administrative process.¹⁴⁸

146. 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/>.

147. 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.

148. N.D. CENT. 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

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 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.¹⁴⁹

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.¹⁵⁰ 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.¹⁵¹

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.*, (Jan. 2011), <http://www.bwenergy.com/News/documents/TroubleshootingUncertainMineralOwnershipinMontana.pdf>.

149. North Dakota Surface Owner Protection Act, N.D. CENT. CODE Ch. 38-11.1 and Oklahoma Surface Damages Act, OKLA. STAT. tit. 52, §§ 318.2–318.9.

150. 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.

151. It is estimated that 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*

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 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, or 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 moratorium, 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.¹⁵² 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. Assuming Europe does move forward, it will do so in an evolutionary, not revolutionary, way.

Besides Poland, which has yet to establish recoverable reserves of shale gas, the United Kingdom appears to be moving the most aggressively

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>.

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

toward exploiting shale gas.¹⁵³ 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,¹⁵⁴ and the fact that UK gas production has dropped about 40% in a decade.¹⁵⁵ “While the country imports gas to make up the shortfall, some of that gap is now being met by coal.”¹⁵⁶ Prime Minister David Cameron wrote in the *Daily Telegraph* about why he supports UK shale gas development and associated hydraulic fracturing. Speaking hydraulic fracturing, he said that it will “drive energy bills down, . . . make our country more competitive, . . . create jobs, . . . [and] bring money to local neighborhoods.”¹⁵⁷ To encourage buy in 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% of the revenue of any productive well.¹⁵⁸ The question is will the Cameron administration survive harsh opposition by environmental organizations so that the United Kingdom’s shale gas reserves will actually be developed.

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

154. *New shale gas resource figure for central Britain*, British Geological Society, <http://www.bgs.ac.uk/shalegas/#ad-image-0> (last visited Sep. 7, 2013).

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

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

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

158. *Id.*