THE NEXT GREAT COMPROMISE: A COMPREHENSIVE RESPONSE TO OPPOSITION AGAINST SHALE GAS DEVELOPMENT USING HYDRAULIC FRACTURING IN THE UNITED STATES

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ABSTRACT

By 2015, the United States is poised to overtake the world's current top producer of natural gas, Russia, due to the abundance of American shale gas located in plays such as the now-familiar Marcellus Shale, which encompasses parts of New York, Pennsylvania, certain Appalachian states, and the Barnett Shale, located in North Texas.[1] *The recent rise in shale gas development is due mostly to the combination of horizontal drilling and hydraulic fracturing (also referred to as fracing, fracking, and hydrofracking) technologies.*[2] *The combination of these separate, but established, technologies allows for economical shale gas production.*[3] *This Article describes these key technologies and addresses the major arguments against shale gas development, which are that (1) hydraulic fracturing causes groundwater contamination, (2) shale gas development requires excessive water resource consumption, (3) shale gas production leads to increased climate change effects, (4) shale gas development discourages the promotion of renewable energy sources, and (5) hydraulic fracturing causes earthquakes.*[4] *Upon examination of these widespread arguments, this Article provides responses based on scientific and legal premises, concluding that shale gas offers the United States the unprecedented opportunity to secure its energy supplies from domestic sources, thus minimizing geopolitical risk exposure, while at the same time reducing environmental impact.*[5] *Finally, this Article provides a process by*

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1. *See infra* notes 8, 50 and accompanying text.
2. *See infra* note 8 and accompanying text.
3. *See infra* Part II.
4. *See infra* Part III.
5. *See infra* Part V.

which the disagreeing groups can establish a dialogue about shale gas development, which will be essential to the future of American energy.[6]

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6. *See infra* Part V.

I. INTRODUCTION

"But just as they did in Philadelphia when they were writing the Constitution, sooner or later, you've got to compromise. You've got to start making the compromises that arrive at a consensus and move the country forward."

– Colin Powell[7]

The International Energy Administration (IEA) recently predicted that the United States would surpass Russia to become the world's top producer of natural gas by 2015 and overtake Saudi Arabia as the world's top crude oil producer by 2017.[8] These predictions vindicate President Richard Nixon's goal of energy independence, formed after the 1973 Arab oil embargo.[9] The catalyst for this turnabout began hundreds of millions of years ago in the depths of ancient seas and currently lies thousands of feet below the surface.

Described as "made-in-America energy," shale gas exploration and production is booming.[10] Over the past five years, shale gas has grown from four percent of total United States natural gas supply to more than twenty-five percent.[11] Moreover, during the active drilling period of 2009–2010, the United States temporarily catapulted ahead of Russia as the largest producer of natural gas.[12] If the IEA's predictions are correct, the United States will reclaim the number one position in just two years.[13] If there were an OPEC-like natural gas cartel, lack of American participation would seriously affect, if not nullify, its impact.[14]

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7. Michelle Levi, *Powell: "No Regrets" About Backing Obama*, CBS NEWS (Feb. 21, 2010, 11:40 AM), http://www.cbsnews.com/8301-3460_162-6228759.html (internal quotation marks omitted) (referring to the Great Compromise of 1787, in which the framers established the bicameral congressional representation system, allowing for agreement on the United States Constitution).

8. Elisabeth Rosenthal, *U.S. To Be World's Top Oil Producer in 5 Years, Report Says*, N.Y. TIMES (Nov. 12, 2012), http://www.nytimes.com/2012/11/13/business/energy-environment/report-sees-us-as-top-oil-producer-in-5-years.html; Thomas K. Grose, *U.S. to Overtake Saudi Arabia, Russia as World's Top Energy Producer*, NAT'L GEOGRAPHIC DAILY NEWS (Nov. 12, 2012), http://news.nationalgeographic.com/news/energy/2012/11/121112-iea-us-saudi-oil/.

9. *See* DANIEL YERGIN, THE PRIZE: THE EPIC QUEST FOR OIL, MONEY & POWER 588–614 (2009) [hereinafter YERGIN, THE PRIZE].

10. Claudia Cattaneo, *Shale Gas the Place to Be*, FIN. POST (Jan 30, 2012), http://business.financialpost.com/2012/01/30/shale-gas-the-place-to-be/ (calling the Obama administration's endorsement of shale gas "a major pillar of its made-in-America energy vision").

11. Daniel P. Schrag, *Is Shale Gas Good for Climate Change?*, 141 DAEDALUS, J. AM. ACAD. ARTS & SCI. 2, 72 (2012), *available at* http://cewc.colostate.edu/wp-content/uploads/2012/05/Is-Shale-Gas-Good-for-Climate-Change_Schrag.pdf.

12. *The U.S. Surpassed Russia as World's Leading Producer of Dry Natural Gas in 2009 and 2010*, U.S. ENERGY INFO. ADMIN. (Mar. 13, 2012), www.eia.gov/todayinenergy/detail.cfm?id=5370.

13. Rosenthal, *supra* note 8; Grose, *supra* note 8.

14. *See* Monika Ehrman, *Competition Is a Sin: An Evaluation of the Formation and Effects of a Natural Gas OPEC*, 27 ENERGY L.J. 175 (2006).

Even with this abundance, there is an urgent need to develop domestic natural gas supplies. Although the United States is a large natural gas producer, it consumes more than it produces, resulting in a net deficit.[15] The United States currently makes up this deficit by importing natural gas via pipeline from Canada and, to a far lesser degree, via tanker ship from various countries in the form of liquefied natural gas (LNG).[16] Unlike pipelines, LNG imports require an extensive and expensive infrastructure of LNG gasification terminals, which convert liquefied natural gas into gaseous form for pipeline transport.[17] But neither of these import supplies is completely secure due to the possibility of supply constraints by the exporting countries and various conflicts over potential safety and environmental risks.[18]

The question of energy security and supply has been a concern of multiple presidential administrations.[19] President Nixon first promulgated the goal of American energy independence after the Arab oil embargo in 1973;[20] President George W. Bush noted the country's addiction to oil;[21] and most recently, President Barack Obama advocated the use of American energy, remarking that the country needs "an energy strategy for the future—an all-of-the-above strategy for the 21st century that develops every source of American-made energy."[22] Dependence on foreign energy supplies has been a major concern, most commonly reflected in foreign policies with respect to the Middle East and North Africa.[23] Environmental issues, industry lobby efforts, and international relations have all prevented

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15. INT'L ENERGY AGENCY, 2012 KEY WORLD ENERGY STATISTICS 13 (2012), *available at* http://www.iea.org/publications/freepublications/publication/kwes.pdf. According to the most recent IEA data, the United States is the second largest producer of natural gas in the world, after Russia. *Id.* In percentage terms, the difference between first and second is miniscule. *Id.* Russia produces 20% of the world's supply of natural gas, while the United States produces 19.2%. *Id.* But unlike Russia, the United States is not a net exporter of natural gas. *Id.* Despite its gargantuan production, it remains a net importer of natural gas. *See id.*

16. *See U.S. Natural Gas Imports by Country*, U.S. ENERGY INFO. ADMIN. (Oct. 31, 2013), http://www.eia.gov/dnav/ng/ng_move_impc_s1_a.htm (providing information based on annual period statistics).

17. *See* Susan L. Sakmar, *America's Natural Gas: From Shale Gas to LNG Exports*, 3 HARV. BUS. L. REV. ONLINE 22 (2012) (noting that environmental groups may oppose LNG exports because of the corresponding increase in shale gas development).

18. *See id.*

19. *See* Robert J. Samuelson, *The U.S. May Become Energy-Independent After All*, WASH. POST. (Nov. 14, 2012, 12:16 PM), http://www.washingtonpost.com/blogs/post-partisan/post/the-us-may-become-energy-independent-after-all/2012/11/14/ef8624e4-2e7d-11e2-89d4-040c9330702a_blog.html.

20. *See* YERGIN, THE PRIZE, *supra* note 9, at 617.

21. *See* IAN RUTLEDGE, ADDICTED TO OIL: AMERICA'S RELENTLESS DRIVE FOR ENERGY SECURITY xiii (2006) (referring to George W. Bush, State of the Union Address by the President (Jan. 31, 2006) (transcript available at http://georgewbush-whitehouse.archives.gov/stateoftheunion/2006/)).

22. Barack Obama, *Energy*, THE WHITE HOUSE, http://www.whitehouse.gov/energy/ (last visited Nov. 22, 2013) (internal quotation marks omitted).

23. *See* Barack Obama, Remarks by the President on America's Energy Security (Mar. 30, 2011) (transcript available at http://www.whitehouse.gov/the-press-office/2011/03/30/remarks-president-americas-energy-security).

a comprehensive national energy policy that would address current and potential supply along with corresponding reductions in demand.

Shale gas production is not only critical for security of supply, but also for environmental protection. It is a "bridge fuel," which represents the view that natural gas, used primarily for gas-fired power generation, is a transitional fuel between high greenhouse-gas-emitting coal and low greenhouse-gas-emitting technologies such as renewables.[24] In fact, gas-fired power plants produce "about half of the carbon dioxide emissions as conventional coal plants."[25] Thus, shale gas production provides the United States with an opportunity to reduce its carbon footprint while simultaneously supporting an abundant and secure energy supply.[26] Nevertheless, despite all the aforementioned advantages, shale gas development generates a new set of challenges.[27] Certain groups are concerned about the impacts and demands on water resources and climate change effects.[28] These issues, along with a barrage of media reports ranging from groundwater contamination to earthquakes near producing areas, raise concerns and questions about the future of shale gas production and, in particular, the safety of the hydraulic fracturing process, which is crucial to shale gas development.[29]

But our energy future cannot be examined in a vacuum.[30] Energy demand is rising and the "use of natural gas must be evaluated alongside other energy sources, geopolitics, existing energy infrastructure, opportunity costs, climate impacts, socio-economic realities, and environmental degradation."[31] This country requires another Great Compromise, which will begin with substantive and collaborative dialogue on the future of American energy and the role of shale gas.[32] This discussion should include all stakeholders—the oil and gas industry, environmental groups, the public, academics, and government—and focus on communicating concerns, risks, and benefits of shale gas development.

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24. *See* Joel Kirkland & Climatewire, *Natural Gas Could Serve as 'Bridge' Fuel to Low-Carbon Future*, SCI. AM. (June 25, 2010), http://www.scientificamerican.com/article.cfm?id=natural-gas-could-serve-as-bridge-fuel-to-low-carbon-future.

25. *Id.*

26. *See id.*

27. *See* Schrag, *supra* note 11, at 72. The author uses the terms "oil and gas industry" and "energy industry" interchangeably.

28. *Id.*

29. *See* Symposium, *Environmental and Social Implications of Hydraulic Fracturing and Gas Drilling in the United States: An Integrative Workshop for the Evaluation of the State of Science and Policy*, 22 DUKE ENVTL. L. & POL'Y F. 245, 248 (2012) [hereinafter *Duke Workshop*].

30. *Id.*

31. *Id.*

32. *See* William McKenzie, *Nation Needs a 'Grand Bargain' to Ease Worries About Fracking*, COLUMBUS DISPATCH (Nov. 23, 2012, 6:28 AM), http://www.dispatch.com/content/stories/editorials/2012/11/23/nation-needs-a-grand-bargain-to-ease-worries-about-fracking.html; *see generally Duke Workshop*, *supra* note 29 (noting the need for a productive discussion of our energy future in light of the proliferation of hydraulic fracturing).

This Article is an example of this necessary dialogue and a first step toward compromise.

Part II of this Article provides an overview of shale gas and its required technologies: horizontal drilling and hydraulic fracturing.[33] Part III addresses and responds to the major arguments against shale gas development.[34] These arguments include (1) groundwater contamination, (2) water consumption, (3) climate change, (4) promotion of renewable energy sources, and (5) seismicity.[35] While these arguments are by no means a comprehensive collection of arguments against shale gas development, they do represent those arguments most commonly cited in media, academic journals, and lawsuits.[36] Part IV of this Article provides a broad review of the process required to facilitate discussion between discordant groups and to move toward a middle ground.[37] Finally, Part V offers the author's conclusions.[38] This Article is limited to issues involving domestic shale gas (not shale oil or coalbed methane) and does not focus on regulatory or policy arguments.[39]

II. SHALE GAS OVERVIEW AND TECHNICAL PROCESSES

"The rise [in shale gas] has been helped along by a variety of factors . . . . But the biggest difference was down to the efforts of one man: George Mitchell, . . . who saw the potential for improving a known technology, fracking, to get at the gas. Big oil and gas companies were interested in shale gas but could not make the breakthrough in fracking to get the gas to flow. Mr. Mitchell spent ten years and $6 [million] to crack the problem (surely the best-spent development money in the history of gas). Everyone, he said, told him he was just wasting his time and money."

– The Economist[40]

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33. *See* discussion *infra* Part II.
34. *See* discussion *infra* Part III.
35. *See* discussion *infra* Part III.
36. *See* discussion *infra* Part III.
37. *See* discussion *infra* Part IV.
38. *See* discussion *infra* Part V.
39. *See also* Michael Goldman, *Drilling Into Hydraulic Fracturing and Shale Gas Development: A Texas and Federal Environmental Perspective*, REV. OF OIL & GAS L. XXVII, DALLAS B. ASS'N ENERGY L. SEC. (Aug. 17, 2012) (on file with author) (reviewing existing legislation and regulations); *see generally* GROUNDWATER PROT. COUNCIL, MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES: A PRIMER 25–42 (2009) [hereinafter SHALE GAS PRIMER], *available at* http://fracfocus.org/sites/default/files/publications/shale_gas_primer_2009.pdf (discussing the regulatory framework of the oil and gas industry); Jesica Rivero Gilbert, *Assessing the Risks and Benefits of Hydraulic Fracturing*, 18 MO. ENVTL. L. & POL'Y REV. 169, 177–92 (2012), *available at* http://law.missouri.edu/melpr/recentpublications/Gilbert.pdf (discussing regulatory and policy considerations as they relate to hydraulic fracturing); Hannah Wiseman, *Untested Waters: The Rise of Hydraulic Fracturing in Oil and Gas Production and the Need to Revisit Regulation*, 20 FORDHAM ENVTL. L. REV. 115, 167–92 (2009) (making recommendations for regulatory reform).
40. *Gas Works: Shale Gas is Giving a Big Boost to America's Economy*, ECONOMIST (July 14, 2012), http://www.economist.com/node/21558459.

Shale gas is an unconventional hydrocarbon resource.[41] These resources "have been bypassed by conventional oil and gas recovery technologies for decades, because they were not considered economically feasible to produce."[42] The two critical technologies that changed this thinking are horizontal drilling and hydraulic fracturing.[43] The combination of these techniques, along with vast efforts in geology and engineering, make the development of this resource possible.[44] A critical examination of the risks and benefits of shale gas requires a fundamental understanding of the basic scientific and engineering principles.

A. Shale Gas Background

Shale gas is not a recent discovery.[45] First explored in the late nineteenth century, shale wells were drilled using unsophisticated drilling techniques and were largely unsuccessful.[46] The first shale gas well in the United States was drilled in 1821, in Fredonia, New York,[47] where the town residents used the produced gas for lighting.[48] The Marcellus Shale was formally identified in the 1930s, but the wells produced for very short durations, so drillers quickly passed them over for other prospects.[49] It was only after 2004 that geologists recognized the potential of the Marcellus Shale as a reservoir rock that would produce natural gas.[50]

A conventional hydrocarbon system is composed of (1) a source rock, (2) a migration pathway, (3) reservoir rock, and (4) seal rock.[51] The source rock is the hydrocarbon origin; the general scientific consensus is that hydrocarbons formed after organic material was buried by sediment and

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41. *See* SHALE GAS PRIMER, *supra* note 39, at 15 (explaining the difference between conventional and unconventional reservoirs).

42. *Unconventional Resources*, PETROLEUM TECH. TRANSFER COUNCIL, http://www.pttc.org/tech_centers/unconventional/unconventional_wp.pdf (last visited Nov. 22, 2013); *see* HOWARD R. WILLIAMS & CHARLES J. MEYERS, MANUAL OF OIL AND GAS TERMS 1020 (Patrick H. Martin & Bruce M. Kramer eds., 14th ed. 2009) (defining unconventional gas).

43. *See Energy in Brief: What Is Shale Gas and Why Is It Important*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm (last updated Dec. 5, 2012).

44. *See id.*

45. *See* SHALE GAS PRIMER, *supra* note 39, at 13.

46. Jim Saiers, *Emerging Issues in Shale Gas Development for the Yale Center for Environmental Law and Policy Workshop Webinar Series* (Oct. 18, 2012), http://environment.yale.edu/envirocenter/post/shale-gas-development-and-its-environmental-implications/ (last visited Nov. 16, 2012); *see* DANIEL YERGIN, THE QUEST: ENERGY SECURITY, AND THE REMAKING OF THE MODERN WORLD 326 (2011) [hereinafter YERGIN, THE QUEST].

47. YERGIN, THE QUEST, *supra* note 46.

48. SHALE GAS PRIMER, *supra* note 39, at 13.

49. Saiers, *supra* note 46.

50. *See* Press Release, U.S. Geological Survey, USGS Releases New Assessment of Gas Resources in the Marcellus Shale, Appalachian Basin (Aug. 23, 2011), *available at* http://www.usgs.gov/newsroom/article.asp?ID=2893&from=rss_home#.UKBvV4UwJSM (noting that the Marcellus Shale was once thought to be a regional source rock that generated natural gas).

51. *See infra* text accompanying notes 52–55.

transformed under high heat and pressure for millions of years.[52] The resulting hydrocarbons moved along a migration pathway into the reservoir rock where they accumulated.[53] The reservoir rock's pore spaces store hydrocarbons, much like a kitchen sponge stores water.[54] The seal rock acts as an impermeable barrier over the reservoir rock and prevents further migration to the surface, much like the cap on a soda bottle prevents carbon dioxide from escaping.[55] But an unconventional hydrocarbon system consists of only a single rock that acts as a combined source, reservoir, and seal rock.[56] The main difficulty in producing shale gas is that the geologic shale structure traps gas molecules tightly within the rock.[57]

In traditional petroleum geology and engineering, sandstones are considered high-quality reservoir rocks with high porosity and high permeability, while shales are considered high-quality seal rocks with low porosity and low permeability.[58] One man would upset this traditional thinking, and as a result, revolutionize petroleum engineering and the energy industry. His name is George P. Mitchell, and he is the father of shale gas.[59]

Born to Greek immigrant parents in Galveston, Texas, Mitchell attended Texas A&M University, graduating first in his class in petroleum engineering.[60] He founded Mitchell Energy & Development Corporation, an independent oil and gas company headquartered in a small suburb forty miles north of Houston.[61] Over the course of almost three decades, and backed in part by the United States Department of Energy (DOE),[62]

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52. *See* Leonardo Maugeri, *Squeezing More Oil From the Ground*, SCI. AM, Oct. 2009, at 57, *available at* http://www.scientificamerican.com/article.cfm?id=squeezing-more-oil-edit-this (originally published online on Apr. 1, 2009, as *Squeezing More Oil Out of the Ground*).

53. *See* Stuart Haszeldine, *Geological Factors in Framing Legislation to Enable and Regulate Storage of Carbon Dioxide Deep in the Ground*, *in* CARBON CAPTURE AND STORAGE: EMERGING LEGAL AND REGULATORY ISSUES 7, 7 (Ian Havercroft et al. eds., 2011); *see also Carbon Dioxide Capture and Sequestration*, ENVTL. PROT. AGENCY, http://www.epa.gov/climatechange/ccs/ (last visited Dec. 12, 2012) [hereinafter EPA, CCS] (explaining what CCS is and its importance).

54. *See* SHALE GAS PRIMER, *supra* note 39, at 15.

55. *See* sources cited *supra* note 53.

56. YERGIN, THE QUEST, *supra* note 46.

57. *Id.*

58. WILLIAMS & MEYERS, *supra* note 42, at 700, 729. The authors note that there are low porosity and low permeability sandstones, so this statement is a generalization. *Id.* Porosity is the measure of porous space within the rock structure, whereas permeability is the measure of a rock's ability to transmit fluid. *Id.*

59. Saiers, *supra* note 46.

60. YERGIN, THE QUEST, *supra* note 46, at 325–26.

61. *Id.*

62. Interview by Michael Schellenberger with Dan Steward, Former Vice President, Mitchell Energy (Dec. 12, 2011) (transcript available at http://thebreakthrough.org/archive/interview_with_dan_steward_for) [hereinafter Interview with Dan Steward] ("Mitchell Energy's first horizontal well was subsidized by the federal government . . . . 'They did a hell of a lot of work . . . and I can't give them enough credit for that. DOE started it, and other people took the ball and ran with it. You cannot diminish DOE's involvement.'").

Mitchell's company spent millions of dollars to develop a highly specialized process that would allow economic production from shale.[63] The final process combined two technologies, horizontal drilling and hydraulic fracturing, providing companies with a method to extract commercial quantities of gas.[64] Without Mitchell's pioneering efforts, shale gas would have remained elusive—the industry aware of its existence, but unable to exploit it.

B. Shale Gas Production Technologies

The oil and gas industry was using horizontal drilling and hydraulic fracturing long before Mitchell, whose triumph resulted from the pairing of those two technologies for shale gas development.[65]

1. Horizontal Drilling

Subsurface rock formations are like layers of a cake.[66] While a vertical well accesses one point in each cake layer, a horizontal well turns sideways and accesses the entire length of the layer.[67] This process only became possible in the 1970s with the advent of steering technology.[68]

Every horizontal well begins by drilling a vertical wellbore.[69] Once the well reaches a sufficient depth, a hydraulic motor mounted directly above the drill bit is steered through a curved section that typically has a radius of 300–500 feet.[70] To continue drilling the horizontal portion, called the "lateral," the drill bit uses the same technique as the vertical portion of the well, only at a ninety-degree angle.[71] Lateral length varies depending on geology and oil and gas lease acquisition, but generally ranges from 1,000 to more than 5,000 feet.[72] When drilling finishes, the well is lined with steel casing, cemented to isolate and protect groundwater, and prepared for hydraulic fracturing operations.[73]

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63. *Id.*
64. YERGIN, THE QUEST, *supra* note 46, at 325–26.
65. Interview with Dan Steward, *supra* note 62.
66. *See* SHALE GAS PRIMER, *supra* note 39, at 14.
67. *See id.* at 46–47.
68. *See id.* at 7.
69. *See id.* at 58.
70. Lynn Helms, *Horizontal Drilling*, 35 DMR NEWSLETTER, no. 1, 2008 at 1, *available at* https://www.dmr.nd.gov/ndgs/newsletter/NL0308/pdfs/Horizontal.pdf.
71. *See* Maugeri, *supra* note 52, at 57.
72. SHALE GAS PRIMER, *supra* note 39, at 58.
73. *Id.* at 51–52.

2. Hydraulic Fracturing[74]

Hydraulic fracturing has been used on vertical wells since the 1940s.[75] The technique allows petroleum engineers to increase hydrocarbon production and is necessary for economical recovery of shale gas.[76]

After drilling, engineers divide the lateral section into stages, each approximately fifty to eighty feet in length.[77] The number of stages depends on the length of the lateral, but eight to ten is typical.[78] A perforating gun is inserted into the well to create holes in the casing, through the surrounding cement, and into the shale formation using explosive charges.[79] Next, a hydraulic fracturing crew assembles the necessary equipment, which may consist of (1) a data monitoring van, (2) frac pumps, (3) a frac blender, (4) proppant storage trucks, (5) water storage tanks, and (6) chemical storage trucks.[80] This equipment works together to pump a mixture of water, chemical additives, and proppant[81] into the wellbore.[82] Water is the largest component of the fracturing fluid, comprising 98%–99% of the total volume.[83] This water is hauled from a water impoundment storage unit, typically a pond, or sometimes brought in from another area using temporary polyethylene pipe and stored in tanks at the wellsite.[84] The operator purchases water from either a surface owner's ponds or wells or a commercial or municipal source.[85] Various chemicals may be added to improve the efficacy of the fluids; each chemical performs a specific function that aids in the fracturing process.[86] Additives include friction reducers to help the fluids flow more easily, stabilizers to prevent corrosion of pipes, and other chemicals to protect the formation.[87] The use

74. Hydraulic fracturing is sometimes referred to as "fracing," "fracking," "hydro-fracking," or "hydrofracking."

75. *See* Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 7 (Tex. 2008) (stating that the technique was first used commercially in 1949).

76. SHALE GAS PRIMER, *supra* note 39, at 9.

77. *Id.* at 58.

78. Chesapeake Energy Corp., *Chesapeake Energy Hydraulic Fracturing Method*, YOUTUBE (Jan. 13, 2011), http://www.youtube.com/watch?v=7ned5L04o8w [hereinafter CHESAPEAKE, HYDRAULIC FRACTURING VIDEO].

79. *Id.*; *see* CHING H. YEW, MECHANICS OF HYDRAULIC FRACTURING 6 (1997).

80. *See* CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

81. WILLIAMS & MEYERS, *supra* note 42, at 779 (noting that proppant consists of "[s]mall granules contained in a slurry mix injected as part of a hydraulic fracturing operation that is designed to keep the pore spaces open after the initial injection of fluids under high pressure").

82. *See* CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

83. SHALE GAS PRIMER, *supra* note 39, at 61.

84. *See* CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

85. *See* SHALE GAS PRIMER, *supra* note 39, at 65. The authors note that older oil and gas leases often provide that the lessee (operator) can use any on-lease water without additional cost, but those types of provisions are no longer commonplace. *Id.*

86. *See* SHALE GAS PRIMER, *supra* note 39, at 60–64.

87. *Chemical Use in Hydraulic Fracturing: What Chemicals Are Used*, FRACFOCUS, http://fracfocus.org/chemical-use/what-chemicals-are-used (last visited Nov. 23, 2013).

of these additives is perhaps the most controversial aspect of hydraulic fracturing.

Water and chemical additives are blended together and transferred to pump trucks, which increase fluid pressure.[88] The high-pressure mixture then flows into the wellbore through a series of pipes and valves.[89] Onsite, the data monitoring van contains a series of computers where engineers and supervisory staff monitor downhole pressures, temperatures, flow rates, and other data as the operation progresses.[90]

Once at the bottom, the fracturing mixture flows through the perforations, where pressure begins to build and ultimately overcomes the tensile strength of the rock.[91] The resulting fractures occur along natural zones of weakness, just as ice on a frozen pond cracks when weight is placed upon it.[92] The fracture dimensions are specifically designed for the unique reservoir, well, and area characteristics,[93] but are typically a fraction of an inch in width and up to several hundred feet in length.[94] After these fractures are created, proppant is added to the mixture.[95] Sand is the most common type of proppant, but ceramic beads and bauxite may be used.[96] The tiny granules act like millions of wedges, helping prop open the newly formed fractures within the rock.[97] This sequence of perforating and hydraulic fracturing is performed on each stage until the entire horizontal wellbore has been treated.[98] Isolation plugs are used to prevent fluid movement between the stages.[99]

Once all stages are fractured and isolation plugs removed, the injected fluids flow back up the wellbore to the surface and into flowback tanks, leaving the proppant behind.[100] This return fluid stream, called "flowback," is composed of the injected hydraulic fluid and may contain natural formation water (typically brine).[101] It may also contain low levels of

88. *See* CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

89. *See id.*

90. SHALE GAS PRIMER, *supra* note 39, at 60–61; *see* CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

91. CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

92. Coastal Oil & Gas Corp. v. Garza Energy Trust, 268 S.W.3d 1, 6 (Tex. 2008); CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

93. SHALE GAS PRIMER, *supra* note 39, at 56–58.

94. *Hydraulic Fracturing Frequently Asked Questions*, R.R. COMM'N OF TEX., http://www.rrc.state.tx.us/about/faqs/hydraulicfracturing.php (last visited Nov. 23, 2013) [hereinafter TEX. RRC FAQ].

95. *See Coastal Oil & Gas Corp.*, 268 S.W.3d at 6–7.

96. *Id.* at 6.

97. *Id.* at 6–7.

98. *Facts on Hydraulic Fracturing*, PA. INDEP. OIL & GAS ASS'N, www.pioga.org/environment-safety/hydraulic-fracturing/ (last visited Nov. 23, 2013).

99. CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

100. *Coastal Oil & Gas Corp.*, 268 S.W.3d at 6–7; CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

101. SHALE GAS PRIMER, *supra* note 39, at ES-4.

naturally occurring radioactive material found within the rock.[102] Flowback volume depends mainly on the reservoir rock's characteristics, but in most cases, recovery is far less than fifty percent.[103] Because of its toxicity, flowback fluid must be disposed of according to governing regulations, usually by transporting it to a commercial treatment facility or injecting it into a subsurface disposal well.[104] Both of these disposal options involve risks that will be discussed later.[105] A scientific understanding of shale gas development provides the foundation for an informed analysis of its risks and benefits.

III. MAJOR ARGUMENTS AGAINST AND RESPONSES IN SUPPORT OF SHALE GAS PRODUCTION

"Extraordinary claims require extraordinary evidence."
– Carl Sagan[106]

Shale gas appears to be a panacea for the country's energy demands.[107] As noted earlier, the United States currently requires a vast amount of hydrocarbons to sustain its appetite for residential, commercial, and industrial uses; shale gas can provide a large and reliable quantity of domestic energy.[108] The benefits of shale gas development also include job creation; increased tax revenues at the local, state, and federal levels; decreased geopolitical risk and defense spending resulting from reduction in exposure to foreign supplies and, therefore, foreign conflict; and reduced greenhouse gas (GHG) emissions when compared to coal.[109] But opponents to shale gas development argue that the risks to human health and the

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102. R. FISHER, GEOLOGIC, GEOCHEMICAL, AND GEOGRAPHIC CONTROLS ON NORM IN PRODUCED WATER FROM TEXAS OIL, GAS, AND GEOTHERMAL RESERVOIRS: FINAL REPORT 3 (1995), *available at* http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/CHEME%206666%20Lecture %20Series-2011/CHEME%206666_14_Fisher_DOE_NORM.pdf (noting that "[s]mall quantities of naturally occurring radioactive materials (NORM) occur in nearly all geologic media and contained fluids"); SHALE GAS PRIMER, *supra* note 39, at ES-4–ES-5.

103. Bill Chameides, *Natural Gas, Hydrofracking and Safety: The Three Faces of Fracking Water*, THE GREENGROK (Sept. 20, 2011), blogs.nicholas.duke.edu/thegreengrok/frackingwater/.

104. *See Coastal Oil & Gas Corp*, 268 S.W.3d at 6–7; CHESAPEAKE, HYDRAULIC FRACTURING VIDEO, *supra* note 78.

105. *See infra* Part III.A.3.

106. *Cosmos: Encyclopaedia Galactica* (PBS television broadcast Dec. 14, 1980), *recording available at* http://www.tv.com/shows/cosmos/encyclopaedia-galactica-357745/.

107. *See* Kirkland & Climatewire, *supra* note 24.

108. *See* Schrag, *supra* note 11.

109. *See* John Deutch, *The Good News About Gas: The Natural Gas Revolution and Its Consequences*, FOREIGN AFFAIRS (Jan./Feb. 2011), http://www.foreign affairs.com/articles/67039/john-deutch/the-good-news-about-gas; IHS Global Insight Inc., *The Economic and Employment Contributions of Shale Gas in the U.S.*, IHS GLOBAL INSIGHT (2011), http://www.ihs.com/pdfs/Shale_Gas_Economic_Impact_mar2012.pdf; *U.S. Shale Gas Benefits*, AM.'S NATURAL GAS ALLIANCE, http://anga.us/issues-and-policy/jobs/us-shale-gas-benefits#.umf17zu7g21 (last visited Nov. 23, 2013).

environment are too great to ignore.[110] They advocate for a delay (e.g., a moratorium) or even prohibition on development.[111] So any conversation between supporters and opponents of shale gas development requires an examination and discussion of potential harms, which should not be discounted. Conversely, this discussion should not support proscriptions on development, which immediately reduce or eliminate the aforementioned benefits. Rather, it can be done simultaneously with development to capture the immediate supply, economic, and environmental benefits, while monitoring for adverse effects and adapting processes where necessary.

A. Argument: Hydraulic Fracturing Contaminates Groundwater

Groundwater contamination is likely the most troubling risk of shale gas development and hydraulic fracturing in particular. Opponents argue that the chemicals in hydraulic fracturing fluid, produced methane, or both can contaminate groundwater sources.[112] Persistent media coverage and litigation have kept this issue at the forefront of discussion without adequate response or dialogue.[113]

1. Argument that Groundwater Is Contaminated By Chemicals in Fracturing Fluid and Subsurface Methane

Litigation involving groundwater contamination by fracturing fluid chemicals is occurring in several states, including Texas, New York, Arkansas, Ohio, and Pennsylvania.[114] These cases typically allege that the

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110. *See, e.g.*, Theo Colborn et al., *Natural Gas Operations from a Public Health Perspective*, 17 HUM. & ECOLOGICAL RISK ASSESSMENT 1039 (2011); Steffen Jenner & Alberto J. Lamadrid, *Shale Gas vs. Coal: Policy Implications from Environmental Impact Comparisons of Shale Gas, Conventional Gas, and Coal on Air, Water, and Land in the United States*, 53 ENERGY POLICY 442 (2013).

111. *See, e.g.*, Timothy B. Wheeler, *Two-Year Delay Proposed in Shale Gas Drilling*, THE BALT. SUN (Feb. 23, 2011), http://articles.baltimoresun.com/2011-02-23/features/bs-gr-natural-gas-drilling-20110223_ 1_shale-gas-drilling-samson-resources-natural-gas.

112. Lynn Kerr McKay et al., *Science and the Reasonable Development of Marcellus Shale Natural Gas Resources in Pennsylvania and New York*, 32 ENERGY L.J. 125, 137–38 (2011); *see also* Fiorentino v. Cabot Oil & Gas Corp., 750 F. Supp. 2d 506, 509 (M.D. Pa. 2010) (complaining that fracturing fluids used by operator Cabot Oil & Gas Corporation included carcinogenic and toxic chemicals that were discharged into the ground, and that diesel fuel, lubricating agents, and other related materials used during the drilling process and well operation contributed to the alleged contamination); Plaintiff's Complaint at Law and in Equity, Armstrong v. Chesapeake Appalachia, LLC, No. 10-CV-000681, 2010 WL 4680899 (Pa. Ct. Com. Pl. Oct. 27, 2010) (complaining of contamination and pollution caused by chemical and waste discharge from drilling and exploration activities).

113. *See* sources cited *supra* note 112.

114. *See, e.g.*, Baker v. Anschutz Exploration Corp., No. 11-cv-6119 CJS, 2013 WL 3282880 (W.D.N.Y. June 27, 2013); Boggs v. Landmark 4 LLC, No. 1:12 CV 614, 2012 WL 3485288 (N.D. Ohio Aug. 13, 2012) (mem. op.); Tucker v. Sw. Energy Corp., Nos. 1:11-cv-44-DPM, 1:11-cv-45-DPM, 2012 WL 528253 (E.D. Ark. Feb. 17, 2012); Plaintiff's Second Amended Complaint, Scoma v. Chesapeake Energy Corp., No. 3:10-CV-1385-N, 2010 WL 3706170 (N.D. Tex. Aug. 11, 2010); *see* Kenneth M. Klemm & Tyler L. Weidlich, *Anti-Fracking Suits Face Formidable Hurdles: Each Plaintiff*

oil and gas operator contaminated groundwater through drilling and exploration activities, including hydraulic fracturing.[115] For example, in *Berish v. Southwestern Energy Production Co.*, the Pennsylvania court stated that fracturing fluid "includes hazardous chemicals that are toxic and carcinogenic," and that other chemicals used in fracturing operations, such as diesel fuel and lubricating materials, are harmful.[116] In *Berish*, faulty well casing resulted in "pollutants and other industrial waste, including the fracking fluid and other hazardous chemicals such as barium and strontium, [to be] discharged into the ground," which contaminated the plaintiffs' water supply.[117] As a result of the contamination, the plaintiffs were exposed to hazardous materials that created the possibility of present and future health problems in addition to a lowering of their property values.[118] Plaintiffs in other Pennsylvania lawsuits have also similarly complained of contaminated groundwater, alleging that drilling and fracturing activities caused the release and discharge of dangerous chemicals and pollutants into their water supply.[119]

While most of this litigation contends that hydraulic fracturing caused groundwater contamination, proving causation has been difficult.[120] In *Strudley v. Antero Resources Corp.*, a Colorado court dismissed with prejudice the surface-owner plaintiffs' case, which alleged various health issues caused by water and air contamination from the defendant's fracturing operations.[121] The court found that the plaintiffs failed to make a "prima facie showing of exposure and causation."[122] The presence of certain gases and compounds in the plaintiffs' homes was not enough to demonstrate "that a causal connection existed between [their] injuries and the alleged exposure" to the drilling activities.[123] Although causation now appears difficult to prove, increased disclosure of fracturing chemicals and studies on hydraulic fracturing effects by groups such as the United States Environmental Protection Agency (EPA) may not only increase these types

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Has to Present Credible Scientific Evidence of Injury and a Causal Connection to a Specific Fracking Operation, NAT'L L.J. (Dec. 2012), *available at* www.bakerdonelson.com/files/Uploads/Documents/Frackingarticle.pdf; Dave Neslin, *Hydraulic Fracturing Litigation: Recent Developments and Current Issues in Cases Involving Alleged Water Supply Impacts*, ROCKY MOUNTAIN MINERAL LAW FOUNDATION SPECIAL INSTITUTE ON THE WATER-ENERGY NEXUS: ACQUISITION, USE AND DISPOSAL OF WATER FOR ENERGY AND MINERAL DEVELOPMENT (Sept. 14, 2012) (stating that approximately thirty-five lawsuits involving water impact allegations have been filed to date in various states and that no court has yet found that the hydraulic fracturing process contaminated water).

115. *See* sources cited *supra* note 114.

116. Berish v. Sw. Energy Prod. Co., 763 F. Supp. 2d 702, 703–04 (M.D. Pa. 2011).

117. *Id.*

118. *Id.* at 702, 704.

119. *See supra* note 112 and accompanying text.

120. Klemm & Weidlich, *supra* note 114.

121. Strudley v. Antero Res. Corp., 2011CV2218, 2012 WL 1932470, at *7 (Colo. Dist. Ct. May 9, 2012), *rev'd*, 2013 WL 3427901, No. 12CA1251 (Colo. App. July 3, 2013).

122. *Id.* at *2.

123. *Id.* at *6; Klemm & Weidlich, *supra* note 114.

of litigation claims against oil and gas companies, but also may allow plaintiffs to overcome evidentiary burdens.[124]

In the film *Gasland*, the iconic image of methane-contaminated groundwater appears when a stream of tap water is set on fire.[125] The presumption is that methane, which is the main component of natural gas, has migrated from the hydraulically fractured wellbore into the groundwater and up into residential wells.[126] After investigating these concerns, a team of scientists at the Nicholas School of the Environment at Duke University published its findings in 2011 in the Proceedings of the National Academy of Science.[127] The Duke scientists "sought to evaluate the potential health and safety impacts of hydraulic fracturing and gas-well drilling by examining private groundwater systems and aquifers overlying the Marcellus and Utica shale formations in northeastern Pennsylvania and upstate New York."[128] They compared water wells that were within one kilometer of active drilling areas with those not in the proximity of active drilling areas.[129] The study concluded that there was "systematic evidence for methane contamination of drinking water associated with shale gas extraction."[130]

In September 2012, the EPA published results on its study of groundwater contamination near Pavillion, Wyoming, which was initiated in 2008, after town residents complained of adverse changes in domestic well water.[131] The EPA's 2011 draft results implicating methane contamination were criticized due to unsound procedures,[132] which resulted in the United States Geological Survey (USGS) conducting a second set of

124. Klemm & Weidlich, *supra* note 114 (commenting that these lawsuits may not be suitable for mass tort litigation as "the resolution of each suit will undoubtedly be resolved on a case-specific (or well-specific) basis [and that e]ach plaintiff will have to present credible evidence of being exposed to and sustaining injury from a harmful chemical and also will have to establish a causal connection to a defendant's operations at each specific well").

125. GASLAND (International WOW Co., in association with HBO Documentary Films 2010).

126. *See id.*

127. Stephen G. Osborn et al., *Methane Contamination of Drinking Water Accompanying Gas-Well Drilling and Hydraulic Fracturing*, 108 PROC. NAT'L ACAD. SCI. 8172, 8172 (2011).

128. Liz Thomas, *Shale-Gas Extraction and Hydraulic Fracturing Accompany Methane Contamination of Drinking Water*, YALE ENV'T REV. (Sept. 18, 2012), *available at* http://environment.yale.edu/yer/article/methane-contamination.

129. Osborn et al., *supra* note 127; Thomas, *supra* note 128.

130. Osborn et al., *supra* note 127.

131. U.S. ENVTL. PROT. AGENCY, INVESTIGATION OF GROUND WATER CONTAMINATION NEAR PAVILLION, WYOMING, PHASE V SAMPLING EVENT: SUMMARY OF METHODS AND RESULTS (Sept. 2012) [hereinafter EPA, PAVILLION INVESTIGATION], *available at* http://www.shb.com/newsletters/ECU/Etc/InvestigationofGroundWaterContamination.pdf.

132. Christopher Helman, *Questions Emerge on EPA's Wyoming Fracking Study*, FORBES (Dec. 9, 2011, 11:33 AM), http://www.forbes.com/sites/christopherhelman/2011/12/09/questions-emerge-on-epas-wyoming-fracking-study/.

samplings, along with the EPA.[133] The final 2012 study also concluded that hydrocarbons, including methane, were found in the water sources and were likely a result of oil and gas operations.[134] However, Encana, the Canadian natural gas company that operates the Pavillion gas field, denies the link between the compounds found in the two monitor wells and its operations.[135]

Both the hydraulic fracturing fluid and methane contamination concerns caused the State of New York to suspend the permitting of high-volume hydraulic fracturing combined with horizontal drilling.[136] This suspension occurred even though (1) the justification for the moratorium included previous unsupported conclusions that "hydraulic fracturing chemicals injected into the Marcellus Shale formation 'work their way into the regular water supply,'" and (2) "[n]o known instances of groundwater contamination have occurred from previous horizontal drilling or hydraulic fracturing projects in New York State."[137] Other states, such as Maryland and New Jersey, have approved or proposed legislation that delays or prohibits hydraulic fracturing and shale gas development.[138]

2. Response to Argument that Groundwater Is Contaminated by Chemicals in Fracturing Fluid and Subsurface Methane

Proper well completion techniques require the use of multiple layers of steel pipe and cement to protect groundwater and prevent fluid cross-migration in a well. Existing regulations generally provide that all wells must have both surface casing and production casing, which are steel pipes encased in cement.[139] Surface casing, installed specifically to protect groundwater, is run from the surface to below the deepest usable-quality groundwater level.[140] Production casing is installed inside the surface

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133. Press Release, U.S. Geological Survey, USGS Releases Reports on Groundwater-Quality Sampling Near Pavillion, Wyo. (Sept. 26, 2012), *available at* http://www.usgs.gov/newsroom/ article.asp?ID=3410&from=rss_home#.UNU4obamDtY.

134. EPA, PAVILLION INVESTIGATION, *supra* note 131. The EPA has extended the comment period on its results from October 2012 to January 2013. Tennille Tracy, *EPA: Pavillion, Wyoming Natural Gas Site Tests Consistent with Earlier Data*, WORLD OIL ONLINE (Oct. 11, 2012), http://www.worldoil.com/EPA_Pavillion_Wyo_natural_gas_site_tests_consistent_with_earlier_data.html.

135. Tracy, *supra* note 134.

136. McKay et al., *supra* note 112, at 127.

137. *Id.* at 127–28 (alteration in original) (internal quotation marks omitted).

138. Gilbert, *supra* note 39, at 183–84.

139. *See, e.g.*, 43 C.F.R. § 3162.5-2(d) (2012) (federal regulations entitled "Protection of fresh water and other minerals"); N.Y. COMP. CODES R. & REGS. tit. 6, § 554.1 (2013) (New York regulations entitled "Prevention of Pollution and Migration"); OKLA. ADMIN. CODE § 165:10-3-4 (2013) (Oklahoma regulations entitled "Casing, Cementing, Wellhead Equipment, and Cementing Reports"); 25 PA. CODE §§ 78.81–.89 (2013) (Pennsylvania regulations governing "Casing and Cementing"); 16 TEX. ADMIN. CODE § 3.13 (2013) (R.R. Comm'n of Tex., Casing, Cementing, Drilling, and Completion Requirements), *amended by* 2013 Tex. Reg. 304048 (June 7, 2013).

140. TEX. RRC FAQ, *supra* note 94.

casing and extends to the total depth of the well.[141] While some operators inject fracturing fluid down the production casing, many use a third protective layer of steel tubing.[142] Pressure gauges monitor wellbore conditions so that leaks are quickly detected.[143] Thus, for fracturing fluid to contact groundwater, it would need to penetrate three layers of steel pipe and two layers of cement before it could leak into usable water-bearing formations.[144] Operators often test wellbore integrity by using downhole tools such as a cement bond log,[145] which is used to find defects in the cement layers prior to fracturing.[146] In May 2012, the United States Bureau of Land Management (BLM) published proposed regulations regarding hydraulic fracturing on federal and Indian lands, one of which includes a cement bond log requirement.[147]

If a well casing leak allows fracturing fluids to escape into the subsurface, the bulk of fracturing fluid is composed of fresh water.[148] The remaining one to two percent of fracturing fluid includes chemicals "found in common, everyday household products such as laundry detergents, cleaners and beauty products . . . [and] food and beverage items."[149] Other chemicals, "such as pH-adjusting agents and chlorine-based sanitization aides, are found in approximately the same concentration as in [a] backyard swimming pool."[150] But in the interest of promoting dialogue with opponents of shale gas development, the oil and gas industry must not trivialize the concerns of property owners. In other words, even though chlorine is found in swimming pools, no one wants to drink swimming pool

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141. *Id.*
142. *Id.* (noting that this program is typically dependent on fracturing pressure).
143. *Id.*
144. *Id.*
145. Marin Katusa, *Bureaucracy Could Kill the U.S. Shale Gas Industry*, OILPRICE.COM (Nov. 6, 2012, 11:38 PM), http://oilprice.com/Energy/Natural-Gas/Bureaucracy-could-Kill-the-U.S.-Shale-Gas-Industry.html.

> Developers already inject cement to fill the "annulus"—the space between the steel pipe called the well "surface casing" and the wellbore (the hole drilled through earth and rock). Fresh water, in groundwater aquifers, is relatively near the surface. Oil and gas production fluids are isolated from that fresh water by the surface casing and the cement in which it is embedded. Cement is injected through the casing pipe into the bottom of the hole where it pushes back up through the annulus until it completely fills the wellbore surrounding the surface casing all the way to the surface. A bond between that cement and the casing ensures that no contaminants from below find their way into fresh-water zones that the well passes through. A "cement bond log" documents data from a probe of the wellbore that uses sonic technology to detect any gaps or voids in the cement.

Id.
146. SHALE GAS PRIMER, *supra* note 39, at 58.
147. Oil and Gas; Well Stimulation, Including Hydraulic Fracturing, on Federal and Indian Lands, 77 Fed. Reg. 27691-01 (May 11, 2012) (to be codified at 43 C.F.R. pt. 3160) (comments were to be sent on or before July 10, 2012).
148. *See* Dan Holder, *New York Keeps Building Drilling Roadblocks*, AM. OIL & GAS REPORTER, Oct. 2012, at 162.
149. *Id.*
150. *Id.*

water. Moreover, a small fraction of chemicals used in hydraulic fracturing are "(1) known or possible human carcinogens, (2) regulated under the Safe Drinking Water Act for their risks to human health, or (3) listed as hazardous air pollutants under the Clean Air Act."[151] So complaints of groundwater contamination must be taken seriously.

Adding to the miscommunication regarding groundwater contamination is the confusion of the hydraulic fracturing process for shale gas with the hydraulic fracturing process for coalbed methane. Coalbed methane is another type of unconventional gas resource formed during coalification.[152] However, unlike shales, which are typically found at depths of 3,000 feet or more,[153] coalbeds lie near the surface and, therefore, are often in closer proximity to groundwater.[154] Thus, its hydraulic fracturing process requires injection of fracturing fluid near to or even within groundwater sources, thereby increasing the risk of contamination.[155] Although the difference between these fracturing processes is substantial, coalbed methane fracturing and any resulting contamination are often mistaken as evidence of groundwater contamination from shale gas fracturing.[156]

Additional procedures to prevent groundwater contamination include a process called "green completion."[157] Green completions can involve a variety of actions that decrease the risk of contamination or GHG emissions.[158] For example, the Canadian company GASFRAC is investigating waterless fracturing techniques that use non-liquid fracture fluids such as propane and compressed air.[159] But opponents, who argue

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151. MINORITY STAFF OF H.R. COMM. ON ENERGY AND COMMERCE, 112TH CONG., CHEMICALS USED IN HYDRAULIC FRACTURING (Comm. Print 2011), *available at* http://democrats.energycommerce.\house.gov/sites/default/files/documents/Hydraulic-Fracturing-Chemicals-2011-4-18.pdf; *see generally* Elisabeth N. Radow, *Citizen David Tames Gas Goliaths on the Marcellus Shale Stage: Citizen Action as a Form of Dispute Prevention in the Internet Age*, 12 CARDOZO J. CONFLICT RESOL. 373 (2011) (discussing the possible consequences to the environment and human health caused by horizontal hydraulic fracturing).

152. *See* U.S. ENVTL. PROT. AGENCY, EVALUATION OF IMPACTS TO UNDERGROUND SOURCES OF DRINKING WATER BY HYDRAULIC FRACTURING OF COALBED METHANE RESERVOIRS 1-3–1-4 (2004), *available at* http://epa.gov/safewater/uic/pdfs/cbmstudy_attach_uic_ch01_intro.pdf [hereinafter EPA, CBM FRACTURING EVALUATION]; SHALE GAS PRIMER, *supra* note 39, at 15.

153. SHALE GAS PRIMER, *supra* note 39, at 54 (excepting the New Albany and Antrim shales).

154. EPA, CBM FRACTURING EVALUATION, *supra* note 152, at 1–6.

155. *Id.*

156. *See, e.g.*, Legal Envtl. Assistance Found., Inc. v. EPA, 118 F.3d 1467, 1469 (11th Cir. 1997) (stating that hydraulic fracturing should be regulated as underground injection, which would affect shale wells, even though the case at issue involved coalbed methane development); Wiseman, *supra* note 39, at 146 (discussing coalbed methane cases and procedures in conjunction with hydraulic fracturing regulation).

157. *See* Don Kreis & Will Labate, *Fracking and "Green Completion": Still Incomplete*, VERMONT L. SCH., http://watchlist.vermontlaw.edu/fracking-and-%E2%80%98green-completion%E2%80%99-still-incomplete/ (last visited Nov. 24, 2013).

158. *See id.*

159. *See* Conversation with Terry Engelder, Professor, Dep't of Geosciences, Pa. State Univ., in New Haven, Conn. (Nov. 16, 2012) (noting that compressed air may not function as effectively as water

that the lack of environmental or health studies precludes the use of new technologies, impede progress by simultaneously criticizing the older and newer techniques.[160] Other methods of green completions include eliminating or regulating diesel and other unnecessary components within fracturing fluids, as Chesapeake Energy Corporation did in its GreenFrac® Program.[161] The Program was "founded in October 2009 to evaluate the types of additives typically used in the process of hydraulic fracturing . . . to determine their environmental friendliness."[162] The Program eliminates any additive "not critical to the successful completion of the well and determines if greener alternatives are available for all essential additives."[163] In recognition of these initiatives, the EPA recently approved new rules requiring operators to perform green completions, which, in part, immediately prohibit venting of natural gas and require development of technologies to capture fugitive emissions.[164] The EPA's recent amendment of these proposed rules allows a two-year transition period during which "producers will have the option until 2015 of either using green completion technology or flaring gas."[165] But beginning January 1, 2015, flaring will no longer be an option.[166]

Both federal and state regulatory agencies are also moving toward mandatory disclosure of fracturing fluid composition, as Texas did in 2011.[167] The Texas Hydraulic Fracturing Fluid Disclosure Bill required companies to disclose fracture fluid components on a well-by-well basis

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as a dispersion medium for proppant and that propane tanks at the wellsite may pose additional onsite storage concerns).

160. *See* Holder, *supra* note 148 (quoting Bradley Gill, the executive director of Independent Oil & Gas Association New York, stating that "[t]he anti-development crowd initially was all in favor of innovative, green fracturing technology, including nonliquid fracture fluids such as propane and compressed air, and other fringe technology . . . . Within two weeks of the announcement that GASFRAC was going to do two test fractures in New York using its technology, the opposition groups came out screaming against it. They said it had not been tested enough, or there were no health impact studies.").

161. *Green Frac®*, CHESAPEAKE ENERGY CORP., http://www.chk.com/Operations/Process/Pages/Green-Frac.aspx (last visited Nov. 24, 2013).

162. *Id.*; *see also Green Completions Now the Standard in Barnett Shale*, http://www.dvn.com/CorpResp/initiatives/Pages/GreenCompletions.aspx#terms?disclaimer=yes (last visited Nov. 24, 2013) ("Green completions have been Devon's standard practice in the Barnett Shale since 2004. The company uses the same process to complete wells in New Mexico, Wyoming, Oklahoma and south Texas.").

163. *Green Frac®*, *supra* note 161.

164. *See* ENVTL. PROT. AGENCY, EPA'S AIR RULES FOR THE OIL & NATURAL GAS INDUSTRY: SUMMARY OF REQUIREMENTS FOR PROCESSES AND EQUIPMENT AT NATURAL GAS WELL SITES 1 (2012) [hereinafter EPA'S AIR RULES], *available at* http://www.epa.gov/airquality/oilandgas/pdfs/20120417summarywellsites.pdf.

165. Karen Boman, *EPA Delays Hydraulic Fracturing Green Completion Rule Until 2015*, RIGZONE (Apr. 18, 2012), http://www.rigzone.com/news/article.asp?a_id=117050. The author notes that the draft rules except exploratory wells not connected to pipeline. *Id.*

166. *See* EPA'S AIR RULES, *supra* note 164.

167. *See, e.g.*, Gilbert, *supra* note 39, at 183.

using the publicly available chemical disclosure registry FracFocus.org,[168] which prior to 2011 was available for voluntary self-reporting.[169] But under the new mandatory disclosure requirement, the fracturing fluid supplier or service company performing the fracturing must "provide the Operator with the chemical makeup and concentration of fracturing fluids within fifteen days of completion of the fracturing treatment."[170] On or before that date, the operator uploads the well and fluid information, including composition and volume, to the FracFocus.org website.[171] The rule protects trade secrets by allowing the supplier to withhold certain information, while still providing an opportunity for trade secret claim challenges;[172] there is also an exception for medical injuries.[173] Critics of the disclosure rule argue that "the concentration percentages are misleading, the trade secret protections are too high, and the after-the-fact disclosures are useless."[174] But the requirement is still an effective regulatory technique that provides (1) a short time frame by which to disclose, and (2) penalties for non-disclosure.[175] Other states, such as California, are considering enacting—or have already enacted—disclosure legislation.[176] At the federal level, the

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168. 16 TEX. ADMIN. CODE § 3.29 (2013) (R.R. Comm'n of Tex., Hydraulic Fracturing Chemical Disclosure Requirements); Tex. S.B. 1049, 82d Leg., R.S. (2011) (enacted); Tex. H.B. 3328, 82d Leg., R.S. (2011) (enacted).

169. *See* FRACFOCUS, http://fracfocus.org/ (last visited Nov. 24, 2013).

170. *Alert – Texas Adds Hydraulic Fracturing Fluid Disclosure Regulations*, HAMELINE & ECCLESTON (Apr. 10, 2012), http://03646f4.netsolhost.com/?p=218 [hereinafter *Fluid Disclosure Regulations*].

171. ADMIN. § 3.29(c)(1)(A).

172. *Id.* § 3.29(d)(4).

173. *See id*. § 3.29(c)(4). The code provides the following requirements for disclosure to health professionals and emergency responders:

> A supplier, service company or operator may not withhold information related to chemical ingredients used in a hydraulic fracturing treatment, including information identified as a trade secret, from any health professional or emergency responder who needs the information for diagnostic, treatment or other emergency response purposes subject to procedures set forth in 29 Code of Federal Regulations § 1910.1200(i). A supplier, service company or operator must provide directly to a health professional or emergency responder, all information in the person's possession that is required by the health professional or emergency responder, whether or not the information may qualify for trade secret protection under subsection (e) of this section. The person disclosing information to a health professional or emergency responder must include with the disclosure, as soon as circumstances permit, a statement of the health professional's confidentiality obligation. In an emergency situation, the supplier, service company or operator must provide the information immediately upon request to the person who determines that the information is necessary for emergency response or treatment.

Id.

174. *Fluid Disclosure Regulations*, *supra* note 170.

175. *Id.*

176. Gilbert, *supra* note 39, at 183–86.

> The California Legislature is also considering legislation, Assembly Bill 591, which would require oil and gas exploration companies to disclose the amount of water and chemicals used during fracing operations . . . . Colorado approved regulations related to fracing in 2009. Under the regulations, each fracing company is required to maintain a well-by-well chemical inventory . . . . Legislation approved in Wyoming on September

proposed BLM regulations mentioned above would require, *inter alia*, the operator to disclose the components of fracturing fluid, in addition to self-certifying that the fluids comply with all applicable laws, regulations, and rules.[177] The operator would also have to "submit information that [would] allow the BLM to confirm wellbore integrity before, during, and at the conclusion of the stimulation operation."[178]

If methane is found in groundwater, one cannot automatically assume that its presence resulted from the fracturing process or wellbore failure.[179] Methane in groundwater may originate as naturally occurring biogenic methane.[180] To determine whether the methane occurred naturally or subsequent to fracturing operations, companies may conduct groundwater testing.[181] This testing may be done prior to operations to set a base level standard or at proximate sources removed from operations to determine the components of surrounding groundwater.[182] If the groundwater does not contain methane prior to fracturing operations, but methane is later found to be present, the methane could be escaping from a poorly constructed wellbore due to a faulty cementing procedure;[183] however, further testing and analysis will be required, as demonstrated by the results from the EPA Pavillion study, to determine whether actual leakage occurs through the subsurface or, as Encana contends, the methane originates from faulty testing, biogenic sources, or both.[184]

Assuming that the well completion is done correctly, it is highly unlikely that methane from the fractured rock would migrate up into the

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> 15, 2010, requires companies to identify water supply wells, demonstrate wellbore integrity and report chemical use to the Oil and Gas Conservation Commission.

Id. (footnotes omitted).

177. *Abstract of Proposed Rule 1004-AE26*, OFFICE OF INFO. & REG. AFFAIRS, http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201110&RIN=1004-AE26 (last visited Nov. 24, 2013).

178. *Id.*

179. *See* RONALD A. SOTO, BASELINE GROUNDWATER QUALITY FROM 20 DOMESTIC WELLS IN SULLIVAN COUNTY, PENNSYLVANIA, 2012, at 3 (2012), *available at* http://pubs.usgs.gov/sir/2013/5085/support/sir2013-5085.pdf.

180. *See id.*

181. *See, e.g.*, *Groundwater Testing*, ENCANA, http://www.encana.com/environment/water/protection/testing.html (last visited Nov. 24, 2013).

182. *See, e.g.*, CHESAPEAKE ENERGY CORP., *The Environment: Water Quality*, *in* THE PLAY 10 (Fall 2012) (on file with author) (stating that water testing begins three to six months before the company drills its wells).

183. *See* BRIANA MORDICK, RISKS TO DRINKING WATER FROM OIL AND GAS WELLBORE CONSTRUCTION AND INTEGRITY: CASE STUDIES AND LESSONS LEARNED 43 (2013), *available at* http://www2.epa.gov/sites/production/files/documents/riskstodrinkingwaterfromoilandgaswellboreconstructionandintegrity.pdf.

184. Adam Voge, *Encana Calls on EPA to Abandon Pavillion Test Wells*, BILLINGS GAZETTE (Dec. 6, 2012, 11:45 PM), http://billingsgazette.com/news/state-and-regional/wyoming/encana-calls-on-epa-to-abandon-pavillion-test-wells/article_40e32548-b0b6-53ee-bc05-2a831068c4b9.html (stating that Encana argues the EPA's data is inaccurate and that the EPA drilled one of its test wells into a natural gas formation).

groundwater.[185] Based on scientific principles, it is far more likely that methane from the fractured rock would travel through the perforations and into the wellbore.[186] In general, gas molecules move from areas of high pressure to areas of low pressure.[187] Since most shale gas formations are at depths below 6,000 feet, the shale gas molecules are under high pressure.[188] The rock fractures and wellbore perforations allow gas molecules to migrate to the wellbore and then to the surface, which is an area of low pressure.[189] Thus, in order for "fracturing fluid[,] . . . natural gas[,] or oil to affect the [usable quality of water], those substances would have to migrate upwards [through] thousands of feet of rock . . . . [That] is simply geologically impossible."[190] And "[f]or produced water that is recovered at the surface from the well to contaminate fresh water formations, a leak in the heavy steel surface casing and a breach of the other protections would have to occur."[191]

While groundwater contamination is damaging, it is also preventable. Better well completion techniques and compliance with regulatory obligations can prevent fluid migration. For example, in Texas, where the first commercial hydraulically fractured shale gas wells were drilled, there have been relatively few complaints of groundwater contamination.[192] While geology may play a part, strict adherence to well construction standards plays a key role.[193] Recent studies by Duke University—which tested 426 samples of groundwater in the Marcellus Shale—in addition to other studies sponsored by the City of Fort Worth, Texas, and Los Angeles County, California, have found no contamination of groundwater by

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185. *See* Terry Engelder, *Capillary Tension and Imbibition Sequester Frack Fluid in Marcellus Gas Shale*, 109 PROC. NAT'L ACAD. SCI. E3625 (2012).

186. *See id.* (providing a more detailed and technical explanation on why reservoir formation methane is more likely to escape into the wellbore and not migrate into the groundwater).

> Not only is the Marcellus unlikely to leak natural brine through capillary seals, but imbibition ensures that fluids left in the Marcellus will be sequestered permanently.
>
> For those concerned that stimulation by hydraulic fracturing could reopen deep-seated fractures and then move either gas or liquid up thousands of feet on a human time scale, the operation of capillary tension causing imbibition in the Marcellus makes this unlikely.

Id.

187. *See* YEW, *supra* note 79, at 5–6.

188. *See id.* at 98.

189. *See id.* at 98–99.

190. *Review of Hydraulic Fracturing Technology and Practices: Hearing Before the H. Comm. on Science, Space, & Tech.*, 112th Cong. 18 (2011) [hereinafter *Review of Hydraulic Fracturing Technology and Practices*], *available at* http://www.gpo.gov/fdsys/pkg/CHRG-112hhrg66221/pdf/CHRG-112hhrg66221.pdf (statement of Elizabeth Ames Jones, Comm'r, Tex. R.R. Comm'n (the Texas oil and gas regulatory agency)).

191. *Id.* at 20.

192. *Id.* (statement of Elizabeth Ames Jones, Comm'r, Tex. R.R. Comm'n, noting that "[t]here is no evidence or history of [groundwater contamination by producer water] ever occurring in Texas"); Bryan Walsh, *The Future of Oil*, TIME, Apr. 9, 2012, at 35.

193. *See* TEX. RRC FAQ, *supra* note 94.

hydraulic fracturing.[194] Although a recent examination by the University of Texas at Austin also came to similar conclusions, it was withdrawn after an independent panel found conflicts of interest and a lack of scientific research.[195] A more comprehensive study authored by the EPA will be publicly released in late 2014.[196] Finally, environmental management technologies will continue to advance as shale gas development increases.[197]

3. Argument that Groundwater Contamination Occurs from Spills and Leaks and Unsound Disposal of Flowback Fluid

Spills and leaks are the most common causes of groundwater contamination in shale gas development operations.[198] For example, in *Fiorentino v. Cabot Oil & Gas Corp.*, sixty-three plaintiffs from the towns of Dimock and Montrose, Pennsylvania, sued oil and gas operator Cabot, alleging that pollutants, industrial or residual waste, diesel fuel, and drilling mud were discharged into the ground near their homes and water wells.[199]

Groundwater contamination may also occur during the disposal of flowback fluid into areas not designed for treatment of such wastes, including municipal waste treatment facilities.[200] In a recent study published by the Society for Risk Analysis, researchers "assessed the likelihood of water contamination from natural gas extraction in the Marcellus Shale."[201] The researchers concluded that, based on a probabilistic model, an individual well could release contaminated fluids, and the majority of release occurs by "transportation spills, well casing

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194. Klemm & Weidlich, *supra* note 114, at 1–2.

195. NORMAN R. AUGUSTINE ET AL., A REVIEW OF THE PROCESSES OF PREPARATION AND DISTRIBUTION OF THE REPORT "FACT-BASED REGULATION FOR ENVIRONMENTAL PROTECTION IN SHALE GAS DEVELOPMENT" 9–11 (2012), *available at* http://www.utexas.edu/news/PDF/Review-of-report.pdf; *see Project Spotlight*, ENERGY INST., UNIV. TEX. AUSTIN (Feb. 21–22, 2013), http://energy.utexas.edu/index.php?option=com_content&view=article&id=152:project-spotlight&catid=35:frontpage-content.

196. Press Release, U.S. Envtl. Prot. Agency, EPA Releases Update on Ongoing Hydraulic Fracturing Study (Dec. 21, 2012), *available at* http://yosemite.epa.gov/opa/admpress.nsf/0/4AF0024955D936EF85257ADB0058AA29; Klemm & Weidlich, *supra* note 114.

197. *See* Sara Murphy, *The Shale Gas Revolution: Risks and Opportunities*, THE MOTLEY FOOL (Dec. 19, 2012), http://m.fool.com/investing/general/2012/12/19/the-shale-gas-revolution-risks-and-opportunities?source=eptyholnk303100 (noting that "[a]n $18 billion industry has risen up strictly to clean up fracking's toxic wastewater. GE . . . makes the Mobile Evaporator, which can be towed from well to well, cleaning up to 50 gallons of wastewater per minute").

198. *See* Fiorentino v. Cabot Oil & Gas Corp., 750 F. Supp. 2d 506, 508, 510–11 (M.D. Pa. 2010) (denying Cabot's motion to dismiss with respect to the aforementioned claims).

199. *Id.*

200. Rodney White, *Marcellus Fracking Poses Risks to Waterways: Study*, GAS DAILY (Aug. 7, 2012), at 4, *available at* http://www.platts.com/latest-news/natural-gas/washington/marcellus-shale-development-poses-risks-to-waterways-6534595.

201. Daniel J. Rozell & Sheldon J. Reaven, *Water Pollution Risk Associated with Natural Gas Extraction from the Marcellus Shale*, 32 RISK ANALYSIS 1, 1 (2012).

leaks, leaks through fractured rock, drilling site discharge, [or] wastewater disposal."[202] The study's authors advised regulators to "consider additional mandatory steps to reduce the potential of drinking water contamination from salts and naturally occurring radioactive materials, such as uranium, radium and radon," as treatment facilities are not typically designed to handle such wastes.[203]

4. Response to Argument that Groundwater Contamination Occurs from Spills and Leaks and Unsound Disposal of Flowback Fluid

Fortunately, prevention of routine spills and leaks is relatively simple. Safety training and hazard response plans can mitigate or prevent surface spills. Most companies implement strict standards and policies for themselves and their vendors with regards to the safe and proper handling of chemicals and fluids.[204] Moreover, industry proponents noted that the aforementioned Risk Analysis study was a theoretical predictive model and did not find any cases of actual contamination, pollution, or migration.[205]

Finally, from an economic perspective, energy companies have no incentive to permit the escape of methane gas or other fluids from the wellbore. First, a poorly designed completion is often expensive to remediate. Second, neither shareholder nor management wants valuable product to escape into the atmosphere or groundwater when it could be captured and sold. Third, not only do companies lose revenue from the escape of methane, but they also become subject to regulatory enforcement and litigation.

B. Argument: Hydraulic Fracturing Consumes Vast Quantities of Water

Water resources are becoming scarce in the United States due to competing activities in the agricultural, power generation, industrial, and residential sectors.[206] The growth of shale gas development is only adding to this widely recognized demand; even the IEA's 2012 World Energy

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202. *Id.*

203. White, *supra* note 200, at 4 (referring to Rozell & Reaven, *supra* note 201).

204. *See Green Frac®*, *supra* note 161. The author notes that federal regulations also govern spill response. *Id.*; *see generally* SHALE GAS PRIMER, *supra* note 39, at 29, 33–35 (discussing the Clean Water Act and the Oil Pollution Act).

205. White, *supra* note 200 (quoting Chris Tucker, spokesman for Energy In Depth).

206. *See* Dana Bohan, *Hydraulic Fracturing and Water Use: Get the Facts*, ENERGY IN DEPTH (July 16, 2013, 12:18 PM), http://www.energyindepth.org/national/hydraulic-fracturing-and-water-use-get-the-facts/. The author notes that Energy in Depth was launched by the Independent Petroleum Association of America. *See generally What's EID?*, ENERGY IN DEPTH, http://www.energyindepth.org/whats-eid/ (last visited Nov. 24, 2013) (explaining the creation, purpose, and focus of Energy in Depth).

Outlook report includes a special section on the burdens placed on water as a result of unconventional resource development.[207]

Water use concerns are especially prevalent in water-poor states such as Texas, Oklahoma, and Colorado, which are all home to substantial shale development.[208] But even in water-plentiful states like Pennsylvania, shale development "is occurring in areas with limited groundwater and small headwater streams, which presents water management challenges in low flow conditions."[209]

1. *Response to Argument that Hydraulic Fracturing Consumes Vast Quantities of Water: Comparative Water Use in Other Sectors*

The amount of water required for hydraulic fracturing varies depending on the formation being fractured, but generally ranges from 3–4.5 million gallons per well.[210] Without context, this volume appears "frighteningly large";[211] however, it is comparable to the amounts of water:

- emptied from the Mississippi River into the Gulf of Mexico every second;[212]
- used by one golf course in 22 days;
- consumed by New York City every six minutes; and
- used by one 1,000 megawatt coal-fired power plant in 10.8 hours.[213]

Properly evaluating fracturing water use requires a comparative analysis, including the relative benefits of other uses of water consumption.

Without question, natural gas produced by hydraulic fracturing provides an essential commodity for millions of Americans.[214] Not only is natural gas a major fuel source for power generation, but it also heats half of all homes in the United States.[215] In comparison, golf courses serve only

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207. INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK 2012 EXECUTIVE SUMMARY 7 (2012), *available at* http://www.iea.org/publications/freepublications/publication/English.pdf (referring to Part D of the report).

208. *See supra* note 206 and accompanying text.

209. Kevin J. Garber et al., *Water Sourcing and Wastewater Disposal: Two of the Least Worrisome Aspects of Marcellus Shale Development in Pennsylvania*, 13 DUQ. BUS. L.J. 169, 174 (2011).

210. Brian J. Smith, Comment, *Fracing the Environment?: An Examination of the Effects and Regulation of Hydraulic Fracturing*, 18 TEX. WESLEYAN L. REV. 129, 132 (2011); SHALE GAS PRIMER, *supra* note 39, at 64 (noting three million gallons is most common); TEX. RRC FAQ, *supra* note 94.

211. *See* sources cited *supra* note 206.

212. Bohan, *supra* note 206.

213. *Hydraulic Fracturing Facts: Water Usage*, CHESAPEAKE ENERGY CORP., http://www.hydraulicfracturing.com/Water-Usage/Pages/Information.aspx (last visited Nov. 16, 2012).

214. *See Oil & Natural Gas Overview: Natural Gas Supply and Demand*, AM. PETROLEUM INST., http://www.api.org/oil-and-natural-gas-overview/exploration-and-production/natural-gas/supply-and-demand.aspx (last visited Nov. 24, 2013).

215. *Id.*

a minute portion of the population. Succinctly, without natural gas, millions of Americans are without power and heat, whereas without golf courses, fewer Americans are without a hobby.

Producing states themselves have tallied the amount of water used for fracturing and have come to the conclusion that it consumes only a small percentage of the overall water used within their states.[216]

- In Texas—the largest onshore producer of oil and gas in the country—the state oil and gas regulatory agency notes that "[t]he amount of water used in hydraulic fracturing is relatively small when compared to other water uses such as agriculture, manufacturing and municipal water supply."[217] According to the Texas Water Development Board, water use for mining activity (which includes oil and gas) was only 0.5% of total consumption as compared to agricultural irrigation, which accounts for roughly 60%.[218]
- In Colorado, another large oil and gas producing state, agriculture and irrigation are also the main uses of water, which account for 85.5% of total consumption.[219]
- Oklahoma found that "energy development plays a relatively minor role in its overall water usage,"[220] stating that, "while significant growth is anticipated in the state's oil and gas industry, that particular use sector is projected to account for only five percent of Oklahoma's total water demand in 2060."[221]
- In Pennsylvania, the state wildlife commission reported that "irrigation and aquaculture practices alone account for over 500 million more gallons of water use *each day* than all natural gas development in the Marcellus Shale."[222] In fact, drilling activities in the Marcellus shale consume less water than "nuclear power generation, agriculture, livestock, irrigation, mining and all public and domestic use."[223]
- In New York, the Department of Environmental Conservation predicted that "peak activity high-volume hydraulic fracturing would result in increased demand for fresh water in New York of 0.24%."[224]

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216. *See* Bohan, *supra* note 206; TEX. RRC FAQ, *supra* note 94.
217. TEX. RRC FAQ, *supra* note 94.
218. *Id.* (noting that percentages can be larger in some localized areas). Information regarding water use associated with oil and gas activities can be found in "Current and Projected Water Use in the Texas Mining and Oil and Gas Industry," by the Texas Water Development Board. *Id.*
219. Bohan, *supra* note 206.
220. *Id.*
221. *Id.*
222. *Id.*
223. *Id.*
224. *Id.* (internal quotation marks omitted).

Even at the federal level, the DOE commented that, "[e]stimates of peak drilling activity in New York, Pennsylvania, and West Virginia indicate that maximum water use in the Marcellus Shale, at the peak of production for each state, assuming 5 million gallons of water per well, would . . . [represent] less than 0.8 percent of the [amount] used" in the same overlying areas.[225]

2. Response to Argument that Hydraulic Fracturing Consumes Vast Quantities of Water: Comparative Water Use in Other Energy Sources

Public perception is that water consumption by other energy sources, especially renewables, is benign. After all, the term "solar power" implies that the energy is derived from the sun and does not affect water resources. Even though certain renewable technologies such as wind consume minimal quantities of water, other energy sources are hidden consumers of water.[226] This consumption must be considered because, although large quantities of water are used in hydraulic fracturing, shale gas still requires less water than many other energy technologies.[227]

The Belfer Center for Science and International Affairs at the Kennedy School of Government at Harvard University conducted a review of the literature for estimates of, among other things, energy-resource extraction's water intensity.[228] The Center found that "the water consumption for the production of shale gas appears to be lower . . . than that for other fossil fuels," including coal mining and washing and U.S. onshore oil production.[229] Thus, increasing shale production or replacing coal sources with natural gas sources could actually "result in reduced water consumption."[230] The Union of Concerned Scientists found that "a typical 500-megawatt coal-fired power plant draws about 2.2 billion gallons of water each year from nearby source[s] to create steam for its turbines—the equivalent of 550 hydraulic fracturing jobs."[231]

Solar power refers to two types of infrastructure—concentrating solar power (sometimes referred to as "solar thermal") and solar photovoltaic

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225. *Id.*

226. *See* ERIK MIELKE ET AL., WATER CONSUMPTION OF ENERGY RESOURCE EXTRACTION, PROCESSING, AND CONVERSION 37 (2010), *available at* http://belfercenter.ksg.harvard.edu/publication/20479/water_consumption_of_energy_resource_extraction_processing_and_conversion.html.

227. *See id.*

228. *Id.* at 6.

229. *Id.*

230. *Id.* (cautioning that "[t]he water used for releasing the gas (hydraulic fracturing), however, has to be carefully managed at a local level").

231. Bohan, *supra* note 206; *see generally Environmental Impacts of Coal Power: Water Use*, UNION OF CONCERNED SCIENTISTS, http://www.ucsusa.org/clean_energy/coalvswind/c02b.html (last visited Nov. 16, 2012) (The Union of Concerned Scientists' official website, on which it documents its findings).

(PV).[232] Concentrating solar power is the most common solar source capable of generating large amounts of power,[233] while solar photovoltaic power creates power primarily to operate batteries for cars, as well as other battery powered objects, and is not feasible on a commercial or industrial basis.[234] Solar thermal technology "deploys long rows of parabolic mirrors to heat a fluid to create steam that drives an electricity-generating turbine."[235] The steam is condensed back into water and cooled for reuse, but water must constantly be replenished to replace evaporative losses.[236] So by design, "solar energy is the most effective in regions where the sun is most intense. As a result, it tends to be most effective in areas with scarce water supplies."[237] This inherent conflict has resulted in the delay of solar project developments "due to massive water needs in areas with little access to natural sources."[238] These water conflicts add to the already contentious disputes in the water-poor and population-rich West.[239] For example, the Mojave Desert solar farm being built by Abengoa Solar will require 705 million gallons of water annually to operate.[240] This amount is equivalent to fracturing more than 176 shale gas wells that, conversely, do not require annual water use—they are largely one-time operations.[241] In 2009, Pacific Gas & Electric, California's largest utility company,[242] announced "it would buy 500 megawatts of electricity from two solar power projects to be built in the California desert."[243] Combined, the operation of these two plants would consume 1.24 billion gallons of water per year.[244] Water consumption will only increase, considering that "35 big solar farm projects [are] undergoing licensing or [are] planned for arid regions of California alone."[245] But like hydraulic fracturing, pressure from regulatory

232. MIELKE ET AL., *supra* note 226, at 36–37.

233. *Id.*

234. *See id.* at 37 (noting that although solar photovoltaic does not require significant water use and is more efficient than CSP, PV is a "less mature" technology).

235. Todd Woody, *Water Use by Solar Projects Intensifies*, N.Y. TIMES GREEN BLOG (Oct. 27, 2009, 9:19 AM), http://green.blogs.nytimes.com/2009/10/27/water-use-by-solar-projects-intensifies/; *see also* MIELKE ET AL., *supra* note 226, at 36–37 (explaining that parabolic mirrors are the most commercially available technology, and therefore, the most commonly used to power electrically generated turbines).

236. Woody, *Water Use by Solar Projects Intensifies*, *supra* note 235.

237. Bohan, *supra* note 206; *see also* MIELKE ET AL., *supra* note 226, at 36 (explaining how areas with a lot of sun are a natural fit for solar energy technology).

238. Bohan, *supra* note 206; *see also* MIELKE ET AL., *supra* note 226, at 36.

239. Woody, *Water Use by Solar Projects Intensifies*, *supra* note 235.

240. *Id.*

241. *Id.*

242. Mark Chediak, *PG&E Faces Revolt Over Smart Grid*, BLOOMBERG BUS. WK.: TECH. (Dec. 30, 2009), http://www.businessweek.com/technology/content/dec2009/tc20091230_147434.htm.

243. Woody, *Water Use by Solar Projects Intensifies*, *supra* note 235.

244. *Id.* "The Genesis Solar Energy Project would consume an estimated 536 million gallons of water a year, while the Mojave Solar Project would pump 705 million gallons annually for power-plant cooling, according to applications filed with the California Energy Commission." *Id.*

245. *Id.*

authorities and failure to receive permits may motivate the solar thermal industry to seek less consumptive technologies.[246] For example, Solar Millennium of Germany is converting its solar power plants to the dry cooling method, which is far more expensive, but requires 90% less water.[247]

Biofuels pose the same water concerns as solar thermal power. Biofuels include such products as "corn ethanol, soy biodiesel, cellulosic ethanol, and microbial biodiesel [and w]hile biofuels are currently controversial, they are the only alternative fuels as yet making any significant contribution to transportation" due to their compatibility with the existing infrastructure.[248] This attractiveness is offset by requirements of "large amounts of water to produce feedstock," creating a problem in arid states like Arizona.[249] And as industrialist and human rights advocate Bill Gates pointed out, "If you're using first-class land for biofuels, then you're competing with the growing of food. And so you're actually spiking food prices by moving energy production into agriculture."[250]

Although shale gas does not currently consume a large fraction of total water resources, if development accelerates and re-fracturing of older wells occurs, water use may climb. Oil and gas companies are interested in reducing consumption, not only to mitigate impacts on potable water, but also to capture economic benefits associated with reducing water-purchase costs.[251] In pursuit of this goal, companies engage in various efforts such as water recycling projects and treatment technologies that make it possible "to recycle water recovered from hydraulic fracturing, including the reuse of treated flowback fluids."[252] They are also evaluating the use of non-potable water sources such as industrial and residential wastewater plants.[253] Undoubtedly, the improvement of technology and shale gas development processes will reduce the volume of water required over time.[254]

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246. *Id.*

247. *Id.* (noting that "[s]olar trough developers prefer to use so-called wet cooling in which water must be constantly . . . replenished to make up for evaporation. Regulators, meanwhile, are pushing developers to use dry cooling, which takes about 90 percent less water but is more expensive and reduces the efficiency—and profitability—of a power plant").

248. CHRISTOPHER HARTO ET AL., LIFE CYCLE WATER CONSUMPTION OF ALTERNATIVE, LOW-CARBON TRANSPORTATION ENERGY SOURCES 3 (2007), *available at* http://wsp.arizona.edu/sites/wsp.arizona.edu/files/Harto%20Final%20Report.pdf.

249. *Id.* at 6.

250. Chris Anderson, *Q&A: Bill Gates on the World's Energy Crisis*, WIRED (June 20, 2011, 2:02 PM), http://www.wired.com/magazine/2011/06/mf_qagates/all/.

251. TEX. RRC FAQ, *supra* note 94.

252. *Id.*

253. *See id.*

254. *See* SHALE GAS PRIMER, *supra* note 39, at 64.

C. Argument: Shale Gas Development Significantly Contributes to Climate Change

Once disputed by the oil and gas industry, climate change is no longer a dubious theory under debate.[255] Accepted by most governments and industries, the consensus is that the earth's climate is changing as a direct result of human activity.[256] Climate change generally refers to any significant change in climate lasting for an extended period of time.[257] These changes include "temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer."[258] Global warming, on the other hand, merely represents one aspect of climate change.

The Intergovernmental Panel on Climate Change concluded in its Fourth Assessment Report "that most of the observed increase in the globally averaged temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations."[259] In fact, greenhouse gas (GHG) levels are currently the highest they have been in the past 650,000 years.[260] Greenhouse gases are those gases such as water vapor, carbon dioxide, methane, nitrous oxide, and certain fluorinated industrial gases[261] that "trap heat in the atmosphere, causing a greenhouse effect."[262] Though these temperature changes appear small when compared to the range of planetary temperatures, slight changes "can translate to large and potentially dangerous shifts in climate and weather," such as "more floods, droughts, or intense rain, as well as more frequent and severe heat waves."[263] Other changes impact the earth's oceans and glaciers, causing increased water acidity, melted ice caps, and a

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255. *See* EXXONMOBIL, OUTLOOK FOR ENERGY: A VIEW TO 2040 at 29 (2012), *available at* http://esso.com.th/Thailand-English/PA/files/2013_eo_eng.pdf (quoting U.N. Secretary General's Advisory Group on Energy and Climate Change); *Climate Change*, BRITISH PETROLEUM, www.bp.com/climatechange (last visited Nov. 24, 2013); *Climate Change*, SHELL.COM, http://www.shell.com/home/content/environment_society/environment/climate_change/ (last visited Nov. 24, 2013).

256. *See* Robert Watson, Director of Strategic Development, Tyndall Ctr. for Climate Change Research, Keynote Address at Yale Law School Conference on Global Climate Change Policy Without the United States: Thinking the Unthinkable (Nov. 9, 2012) [hereinafter Watson, YLS Keynote Address] (Watson was chair of the Intergovernmental Panel on Climate Change from 1997 to 2002).

257. *See Climate Change: Basic Information*, ENVTL. PROT. AGENCY, http://www.epa.gov/climatechange/basics/ (last visited Nov. 24, 2013).

258. *Id.*

259. *Climate Change*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. NAT'L WEATHER SERV. (Oct. 2007), www.nws.noaa.gov/os/brochures/climate/Climatechange.pdf [hereinafter *Climate Change*, NAT'L OCEANIC & ATMOSPHERIC ADMIN.] (internal quotation marks omitted).

260. *Climate Change: Basic Information*, *supra* note 257.

261. *See Climate Change Indicators in the United States: Greenhouse Gases*, ENVTL. PROT. AGENCY, http://www.epa.gov/climatechange/science/indicators/ghg/index.html (last visited Nov. 24, 2013).

262. *Climate Change*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., *supra* note 259.

263. *Climate Change: Basic Information*, *supra* note 257.

rise in sea level.[264] Some of these changes, such as the melting of the ice caps, are irreversible and require immediate action by all levels of government and by all contributors to GHG emissions.[265]

Methane is one of five GHGs covered by the Kyoto Protocol and is very potent in terms of climate change.[266] Its global warming potential (GWP) is twenty-three times greater than that of carbon dioxide, which means that "for a given volume of methane emitted, the resulting global warming effect will be 23 times stronger over one hundred years compared to the same volume of [carbon dioxide]."[267] Interestingly, "methane remains in the atmosphere for a period of approximately 12 years after it has been emitted . . . [while carbon dioxide] is estimated to have an atmospheric lifetime of 50–200 years."[268] "The[se] differences in the GWP and atmospheric lifetimes of methane and [carbon dioxide] mean that methane has a relatively large global warming effect over a short period of time, whereas [carbon dioxide] has a relatively small global warming effect but over a much longer period of time."[269]

Critics argue that the combustion of shale gas contributes to climate change by releasing carbon dioxide, non-combusted methane, and particulate matter into the atmosphere.[270] They also maintain that GHG emissions are released by pipeline and facility leaks, flaring and venting of natural gas, and the escape of methane from flowback fluid into the atmosphere.[271]

Even the coal industry has attempted to reinvent itself in the face of opposition to fossil fuels in favor of cleaner technologies.[272] Marketing itself as "Clean Coal,"[273] this powerful group focuses on the availability of low-sulfur coal from the western United States, as well as newer technologies in coal-fired power plants that produce fewer GHG emissions.[274] Indeed, certain studies have been published stating that, in

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264. *See* Paul M. Barrett, *It's Global Warming, Stupid*, BLOOMBERG BUS. WK.: POLITICS & POLICY (Nov. 1, 2012), http://www.businessweek.com/articles/2012-11-01/its-global-warming-stupid; *Climate Change: Basic Information*, *supra* note 257.

265. *See Climate Change: Basic Information*, *supra* note 257.

266. *See What Is Coal Seam Gas?*, WORLD COAL ASS'N, http://www.worldcoal.org/coal/coal-seam-methane/ (last visited Nov. 24, 2013).

267. *Id.*

268. *Id.*

269. *Id.*

270. *Climate Change: Basic Information*, *supra* note 257.

271. Watson, YLS Keynote Address, *supra* note 256.

272. *See About Us*, AM. COAL. FOR CLEAN COAL ELEC., http://www.cleancoalusa.org/about-us (last visited Nov. 24, 2013) (stating that the Coalition is a partnership of the industries involved in producing electricity from coal).

273. *See id.*

274. Conversation with Carol M. Rose, Professor Emeritus, Yale Law School, in New Haven, Conn. (Fall 2012).

terms of climate change benefits, coal is a better fuel than shale gas.[275] Others advocate the use of coal under the precautionary principle, which is a "[n]ormative principle of environmental law . . . that calls for precaution in the face of uncertainty."[276] These advocates argue that the coal mining process and its effects are a known commodity, while the environmental and other consequences of shale gas development are yet unknown.[277]

Shale gas development opponents argue that shale gas contributes to climate change through the release of methane and carbon dioxide from processes including fracturing, venting or flaring of wells, and pipeline leaks.[278] Flaring or venting typically occurs when a well is in the flowback or initial testing phase.[279] Unlike crude oil, natural gas cannot be produced and stored in a tank onsite until a pipeline connection is made.[280] In these cases, operators may flare the gas into the atmosphere simply because there is no other place to put it, and stopping production may result in permanent reservoir damage.[281] Leaks from unsecured or damaged pipelines are another source of GHG emissions.[282]

Oil and gas companies employ various techniques to prevent venting and flaring.[283] The simplest solution is to construct a pipeline connection before a well begins flowback; that way, engineers can connect the well and immediately flow gas through the sales meter rather than into the atmosphere.[284] For the most part, energy companies work with midstream companies to accomplish this construction; but unfortunately, these plans do not always come to fruition due to construction delays, limited manpower, or stalled contract negotiations. Companies could always delay the fracturing process until a pipeline connection is made, but adjusting drilling schedules can be extremely difficult, as companies frequently establish drilling plans months or even years in advance.

As discussed above, the EPA is prohibiting venting and flaring after 2015, which will lead to the development of alternative emission strategies, such as carbon capture and sequestration (CCS) technology.[285] In the

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275. *See* Robert W. Howarth et al., *Methane and the Greenhouse-Gas Footprint of Natural Gas from Shale Formations: A Letter*, CLIMATIC CHANGE (Mar. 13, 2011), http://sustainablefuture.cornell.edu/news/attachments/Howarth-Et-Al-2011.pdf.

276. JONATHAN R. NASH, ESSENTIALS: ENVIRONMENTAL LAW AND POLICY 175 (2010).

277. E-mail from John S. Lowe, George W. Hutchinson Professor of Energy Law, SMU Dedman School of Law, to Monika Ehrman (Nov. 14, 2012, 15:39 CST) (on file with author).

278. Howarth et al., *supra* note 275.

279. *Id.*

280. *Natural Gas Extraction Portal*: *Well Completion*, ENVTL. COMPLIANCE ASSISTANCE PLATFORM, http://www.envcap.org/ee/well_completion.cfm (last visited Nov. 24, 2013).

281. *See* Howarth et al., *supra* note 275.

282. *See id.*

283. *See* EPA'S AIR RULES, *supra* note 164.

284. *See About Pipelines*, ASS'N OF OIL PIPE LINES, http://www.aopl.org/aboutpipelines/ (last visited Oct. 24, 2013).

285. *See* EPA'S AIR RULES, *supra* note 164.

carbon capture process, carbon dioxide is captured either before or after combustion.[286] The captured carbon dioxide may then be purified and compressed into a liquid state, where it "can be transported . . . by a truck, train, pipeline, or pressurized ocean tanker."[287] In the sequestration process, the captured and pressurized carbon dioxide is injected into identified geologic reservoirs for functions such as enhanced oil recovery or repressurization of depleted oil and gas fields.[288] But the most important attribute of CCS is that the carbon dioxide must be "stored deep below ground for tens of thousands of years . . . . [to] reduce the excess rate, and total mass, of fossil carbon emission, and enable the earth's self-regulating system to return to its equilibrium of the past 10,000 years."[289] The Obama administration supports development of CCS technology, and in 2010 created an Interagency Task Force on Carbon Capture and Storage, which is co-chaired by the EPA and the DOE.[290] The task force was responsible for delivering "a series of recommendations to the president . . . on overcoming the barriers to the widespread, cost-effective deployment of CCS within 10 years."[291]

The reality is that even with these issues and future technologies, shale gas may be an immediately present savior for our planet in the crusade against climate change.[292] Quite simply, the reason is because shale gas produces far fewer emissions than coal, which is the most common source of electric power in the world.[293] In emerging countries, the aggregation of coal-fired power plants to support those burgeoning economies is resulting in massive GHG emissions.[294] Indeed, shale gas's most beneficial characteristic may be that it "emits 50 percent less carbon dioxide than coal . . . [S]o if countries like China and India made the switch on a large scale, then we have a chance to reset the trajectory of global carbon dioxide emissions."[295] As Alan Riley, professor of energy law at City University London, noted, "Unless a cheap, rapidly deployable substitute fuel is found for coal, then it will be next to impossible to safely rein in rising carbon dioxide levels around the world."[296] Encouraging domestic and global

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286. Haszeldine, *supra* note 53, at 7; *see also* EPA, CCS, *supra* note 53.

287. Haszeldine, *supra* note 53, at 7; *see also* EPA, CCS, *supra* note 53.

288. Haszeldine, *supra* note 53, at 7.

289. *Id.* at 8.

290. Press Release, Council on Envtl. Quality, Federal Task Force Sends Recommendations to President on Fostering Clean Coal Technology (Aug. 12, 2010), *available at* http://www.whitehouse.gov/administration/eop/ceq/Press_Releases/August_12_2010.

291. *Id.*

292. *See* Alan Riley, *Shale Gas to the Climate Rescue*, N.Y. TIMES (Aug. 13, 2012), http://www.nytimes.com/2012/08/14/opinion/shale-gas-to-the-climate-rescue.html?_r=1&.

293. INT'L ENERGY AGENCY, 2012 KEY WORLD ENERGY STATISTICS, *supra* note 15, at 24.

294. *See* Riley, *supra* note 292.

295. *Id.*

296. *Id.*

development of shale gas could temper or even reverse the "upward climb of carbon dioxide emissions."[297]

In its series on hydraulic fracturing, the *New York Times* enlisted the efforts of Cornell biochemist Robert Howarth, who claimed that shale gas production resulted in more GHG emissions than coal, which, therefore, outweighed any of its benefits.[298] Based on his industry colleagues' comments, Howarth suspected that flowback fluid contains high amounts of methane gas, which then escape into the atmosphere.[299] Howarth and his team, including Cornell civil and environmental engineering professor, Anthony Ingraffea, analyzed existing data on GHG emissions, concluding that approximately 7.85% of methane gas produced from a well leaks into the atmosphere.[300] Their results encouraged shale gas opponents and outraged its supporters, leading *Time Magazine* to name Howarth and Ingraffea among its one hundred most influential people in 2011.[301]

Both the industry and the scientific community, including Howarth's Cornell colleagues, began questioning his data inputs and conclusions; debates ensued over the next year.[302] It was found that Howarth may have "cherry picked data" and used EPA data that overstated emissions by fifty percent.[303] Lawrence M. Cathles of the Department of Earth and Atmospheric Sciences at Cornell rebutted Howarth's arguments, showing that there *is* conclusive evidence of climate benefits by moving from coal to natural gas, whether from production of conventional or unconventional gas resources.[304] Cathles's rebuttal highlighted several serious flaws in Howarth's analysis, including:

> 1) Unrealistically high estimates of fugitive emissions associated with unconventional gas production based on a cryptic presentation of relatively few and poor primary sources 2) [a] dismissive discussion of new technologies now in use to reduce such emissions 3) [a]n unsupported, and . . . inappropriate[] choice of the time interval for

297. *Id.*
298. *See* Anne Ju, *Researchers Challenge Study on Hydrofracking's Gas Footprint*, WORLD.EDU (Mar. 6, 2012), http://world.edu/researchers-challenge-study-hydrofrackings-gas-footprint/.
299. *Id.*
300. Press Release, Cornell Univ., Response to Howarth et al's Reply (Feb. 29, 2012), *available at* http://www.geo.cornell.edu/eas/PeoplePlaces/Faculty/cathles/Natural%20Gas/Response%20to%20Howarth's%20Reply%20Distributed%20Feb%2030,%202012.pdf.
301. Bryan Walsh, *People Who Mattered: Mark Ruffalo, Anthony Ingraffea, Robert Howarth*, TIME (Dec. 14, 2011), http://content.time.com/time/specials/packages/article/0,28804,2101745_2102309_2102323,00.html.
302. *See* Reid Frazier, *Scientists Square Off Over Fracking's Impact on Climate*, ALLEGHENY FRONT (June 22, 2012), http://www.alleghenyfront.org/story/scientists-square-over-frackings-impact-climate-0 (last updated May 30, 2013).
303. *Id.*
304. *Id.*; Ju, *supra* note 298; Matt Richmond, *Cornell Scientists Face Off Over Danger of Methane Emissions*, INNOVATION TRAIL (Dec. 20, 2011, 10:34 AM), http://innovationtrail.org/post/cornell-scientists-face-over-danger-methane-emissions.

> estimating greenhouse impacts of fugitive methane [and] 4) [c]omparison of gas to coal on a basis (heat rather than electricity) which is basically irrelevant to evaluation of the relative greenhouse effects of these two options.[305]

Cathles concluded that "substitution of [coal with] natural gas reduces global warming by 40% of that which could be attained by the substitution of zero carbon energy sources."[306] Cathles also substantially revised the methane leakage rates, placing them closer to 1.0%–1.5%, as compared to Howarth's 7.85%, stating that the benefit occurs even with these leaks.[307] The Cathles study notes that the "40%-of-zero-carbon benefit would be realized shortly after methane emissions ceased because methane is removed quickly from the atmosphere whereas [carbon dioxide] is not."[308] As Cathles notes, "From a greenhouse point of view it would be better to replace coal electrical facilities with nuclear plants, wind farms, or solar panels, but replacing them with natural gas stations will be faster, cheaper and achieve 40% of the low-carbon-fast benefit . . . ."[309] Ultimately, "[g]as is a natural transition fuel that could represent[] the biggest available stabilization wedge available to us."[310]

Shale gas could be used as a bridge fuel, allowing time for scientists and engineers to develop cost-effective and more environmentally friendly energy sources to replace fossil fuels. But because "[c]urrent renewable energy sources cannot in any way deliver the same savings in carbon emissions that we can achieve by replacing coal with shale gas,"[311] we should promote shale gas development as key to the energy-environment balance.

D. Argument: Renewable Resources Should Be Promoted Over Shale Gas

Renewable resources are often portrayed as the holy grail of energy.[312] They promise a plethora of environmental benefits stemming from their non-combustive, zero-carbon energy sources.[313] Their proponents contend that shale gas, with its abundant and low-cost supply, detracts development

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305. Press Release, Cornell Univ., *supra* note 300.

306. Lawrence M. Cathles, *Assessing the Greenhouse Impact of Natural Gas*, 13 GEOCHEMISTRY, GEOPHYSICS, GEOSYSTEMS, June 6, 2012, no. 6, at 1.

307. *Id.* at 12.

308. *Id.* at 1.

309. *Id.* at 16.

310. *Id.*

311. Riley, *supra* note 292.

312. Sally Deneen, *Green/Renewable Energy*, DAILY GREEN, http://www.thedailygreen.com/living-green/definitions/green-renewable-energy (last visited Nov. 24, 2013).

313. Joe Romm, *The Holy Grail of Clean Energy Economy Is in Sight: Affordable Storage for Wind and Solar*, CLIMATE PROGRESS (Aug. 31, 2009), http://thinkprogress.org/climate/2009/08/31/204578/clean-energy-storage-wind-solar/.

and promotion of renewable resources, as demonstrated by a recent Massachusetts Institute of Technology (MIT) study indicating that continued growth in shale gas would depress the advancement of renewables.[314] Even President Obama's State of the Union addresses reflect the shift in attitudes away from clean technology and "clean energy jobs"[315] to an "all-of-the-above" strategy that includes "a supply of natural gas that can last America nearly 100 years."[316] Professor Paul Stevens of the Centre for Energy, Petroleum, and Mineral Law and Policy at the University of Dundee has stated that "[t]here was previously an assumption that shale gas would act as a substitute for coal, however, now there are increasing worries that it could act as a substitute for renewables."[317] Although shale gas is often heralded as a bridge to a clean energy future, "there had better be something at the other end of the bridge," according to Henry Jacoby, co-director emeritus of MIT's Joint Program on the Science and Policy of Global Change.[318]

The reason for the lack of renewable energy development and infrastructure almost certainly comes down to economics and, to a lesser extent, scalability. In times of economic decline, shale gas is a cheaper method of solving climate change when compared to renewables.[319] This preference remains even though renewables receive an overwhelming 39.5% of federal subsidies—a total of $14.67 billion—and natural gas and petroleum liquids receive only 7.6%.[320] Low-priced natural gas has caused decreased interest in biofuel production and technology investment, which has undoubtedly led to several notable bankruptcies within the sector.[321]

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314. Henry D. Jacoby, Francis M. O'Sullivan & Sergey Paltsev, *The Influence of Shale Gas on U.S. Energy and Environmental Policy*, 1 ECON. ENERGY & ENVTL. POL'Y 37, 47 (2012), *available at* http://globalchange.mit.edu/files/document/MITJPSPGC_Reprint_12-1.pdf.

315. President Barack H. Obama, Remarks by the President in State of the Union Address (Jan. 27, 2010), *available at* http://www.whitehouse.gov/the-press-office/remarks-president-state-union-address.

316. *Id.*

317. *Duke Workshop*, *supra* note 29, at 249; Comments from Carol M. Rose, Professor, Yale Law School, to author (Nov. 25, 2012) (on file with Monika Ehrman); Conor McGlone, *Shale Gas Is Bad News for Renewables Says Leading Think Tank*, EDIEENERGY (Aug. 7, 2012), http://www.edie.net/news/news_story.asp?id=23044 (internal quotation marks omitted); *see also* Paul Stevens, Briefing Paper, *The 'Shale Gas Revolution': Developments and Changes*, CHATHAM HOUSE BRIEFING PAPER 3 (Aug. 2012), *available at* http://www.chathamhouse.org/sites/default/files/public/Research/Energy,%20 Environment%20and% 20Development/bp0812_stevens.pdf.

318. Vicki Ekstrom, *A Shale Gas Revolution? MIT Report Shows Prosperous Shale Gas Market Could Hurt Future R&D, If We Let It*, MIT NEWS (Jan. 3, 2012), http://web.mit.edu/newsoffice/2012/shale-gas-revolution-report.html. Jacoby is also co-author on a report by the MIT Energy Initiative (MITEI) called *The Future of Natural Gas*. *Id.*

319. McGlone, *supra* note 317 (interviewing Professor Stevens).

320. *See* U.S. ENERGY INFO. ADMIN., DIRECT FEDERAL FINANCIAL INTERVENTIONS AND SUBSIDIES IN ENERGY IN FISCAL YEAR 2010 xiii (July 2011), *available at* http://docs.wind-watch.org/US-subsidy-2010.pdf (referring to table showing quantified energy-specific subsidies and support by type for fiscal year 2010).

321. Kevin Bullis, *What Mattered in Energy Innovation This Year: Notable Advances in Renewable Energy Pale Compared to the Impact of Shale Gas*, MIT TECH. REV. (Dec. 29, 2012), http://www.

Additionally, international competition has decimated some domestic renewable industries, namely solar.[322] Chinese manufacturers are able to produce cheaper solar panels due to low silicon prices and government support.[323] Despite receiving over $1.3 billion in federal subsidies,[324] the United States solar technology manufacturers cannot compete. In addition to the cost advantage, some renewables face resistance to their land use requirements. After the recession and shale gas boom, wind power prices are no longer competitive against wholesale electric prices and "NIMBY (Not In My Back Yard) protests have made getting approval for a wind farm in the US as difficult as getting it for a coal-fired plant."[325] Developing renewables' share of the United States energy market will require additional federal and public support. But natural gas commodity prices have historically been volatile, fluctuating with economic growth.[326] As the United States economy emerges from recession, it is likely that higher priced natural gas may increase the attractiveness of renewable investment, but implementation of a carbon tax would almost certainly increase the viability of renewable energy projects.[327]

Moreover, opponents of shale gas production often contend that it should be halted in favor of renewables under the optimistic, but unrealistic assumption that a scalable renewable fuel technology currently exists and is

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technologyreview.com/news/508951/what-mattered-in-energy-innovation-this-year/; *see, e.g.*, Martin LaMonica, *A123 Systems Headed for Chinese Ownership (Again)*, MIT TECH. REV. (Dec. 10, 2012), http://www.technologyreview.com/view/508551/a123-systems-headed-for-chinese-ownership-again/ (acknowledging that A123 Systems' sale to a Chinese company and other similar sales were consequences of "tepid demand for battery-electric and plug-in hybrid vehicles"); Todd Woody, *What Solyndra's Bankruptcy Means for Silicon Valley Solar Startups*, FORBES (Aug. 31, 2011, 3:07 PM), http://www.forbes.com/sites/toddwoody/2011/08/31/what-solyndras-bankruptcy-means-for-silicon-valley-solar-startups/ (noting that solar panel maker Solyndra and other United States solar companies face problems competing internationally).

322. *See* Woody, *What Solyndra's Bankruptcy Means for Silicon Valley Solar Startups*, *supra* note 321 (discussing the high competition the American solar industry faces against inexpensive Chinese manufacturers).

323. Juliet Eilperin, *Why the Clean Tech Boom Went Bust*, WIRED (Jan. 20, 2012, 3:25 PM), http://www.wired.com/magazine/2012/01/ff_solyndra/3/.

324. *See* U.S. ENERGY INFO. ADMIN., DIRECT FEDERAL FINANCIAL INTERVENTIONS AND SUBSIDIES IN ENERGY IN FISCAL YEAR 2010, *supra* note 320, at xiii. Under the U.S. Energy Information Administration (EIA) study, "renewables" include biomass, geothermal, hydro, solar, wind, and biofuels. *Id.* Both biofuels and wind receive more in federal subsidies than do natural gas petroleum liquids. *Id.* Moreover, natural gas and petroleum liquids comprised 25% of power generation sources in 2010, while renewables comprised only 10.3%. *Id.* Despite incentives and small-scale availability, renewables make up only 7% of the residential and commercial sector, while natural gas makes up 75%. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY REVIEW 2011 37 (2012), *available at* http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf.

325. Eilperin, *supra* note 323.

326. *Why Do Natural Gas Prices Fluctuate So Much?*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/why_do_prices_fluctuate/html/ngbro.html (last visited Nov. 24, 2013).

327. McGlone, *supra* note 317.

merely waiting to be deployed.[328] But at this time, there is no renewable energy infrastructure or technology sufficient to replace fossil fuel energy sources. Many of these renewable energy projects either require intense uses of water and other resources to function or cannot function without the dependent renewable source.[329] For example, solar power requires the sun, which means that an alternate backup power source is required at night. Other renewable technologies face challenges due to limited output or low efficiencies.[330] However, renewable development will endure due to continued environmental efforts to address climate change.

The United States cannot afford to rely on a sole energy technology. Interruption or stoppage of shale gas development due to a harsh regulatory environment or commodity price collapse may result in a failure to decrease GHG emissions in time to stave off climate change.[331] Similarly, renewable technologies may face environmental battles over water consumption and land or ocean use, which stall or prohibit development. Indeed, one event can act as a catalyst for the decline of an entire industry, such as the world has seen after the Fukushima nuclear disaster.[332] Thus, the goals of sustainable energy and environmental protection will be achieved not through a technology revolution, but an evolution[333]—one that embraces cooperative projects such as co-generation, which relies on both shale gas and wind or solar energy. This new collaborative effort will become a critical component of our future energy portfolio.[334]

E. Argument: Hydraulic Fracturing Causes Earthquakes

Seismicity is the most unexpected phenomenon of shale gas development. After a spate of earthquakes in areas that have not been historically seismically active, scientists began investigating a possible relationship with shale gas development.[335] Occurring in such states as

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328. *See id.*

329. *See* Smith, *supra* note 210, at 132.

330. Brett Buchheit, *The Economics of Alternative Energy: Decisions Following the IPCC's Report on Climate Change*, 38 TEX. ENVTL. L.J. 73, 81–96 (2008) (stating that (a) biomass has limited output given the size of facilities; (b) production of biofuels (4.8 billion gallons of ethanol a year) is not sufficient to meet demand (140 billion gallons of gasoline a year); and (c) traditional solar panels are inefficient at converting sunlight to energy).

331. *See* Stevens, *supra* note 317, at 4 (stating that it will take time to develop a sustainable renewable energy infrastructure).

332. *See Nuclear Power After Fukushima*, WORLDWATCH INST., http://www.worldwatch.org/nuclear-power-after-fukushima (last visited Nov. 24, 2013).

333. Watson, YLS Keynote Address, *supra* note 256.

334. *See* Elizabeth Burleson & Winslow Burleson, *Innovation Cooperation: Energy Biosciences and Law*, 2011 U. ILL. L. REV. 651, 670 (2011).

335. Matthew Philips, *More Evidence Shows Drilling Causes Earthquakes*, BLOOMBERG BUS. WK.: GLOBAL ECONOMICS (Apr. 1, 2013), http://www.businessweek.com/articles/2013-04-01/more-evidence-that-fracking-causes-earthquakes.

Arkansas, Colorado, Ohio, and Texas,[336] the earthquakes have been small, with few injuries to persons or property. Public concern has led to government and academic studies focusing on hydraulic fracturing and wastewater reinjection.[337] Many of these studies classified hydraulic fracturing as low-risk with respect to seismic causation and concluded that there is no direct evidence that hydraulic fracturing triggers earthquakes.[338] However, at the annual meeting of the American Geophysical Union, Austin Holland of the Oklahoma Geological Survey stated that his studies "suggest that about 2 percent of the oil and gas wells hydraulically fractured in [Oklahoma] in the past [2.5] years were followed within 21 days by a quake within about five miles of the well."[339] Interestingly, Holland's fellow panelists did not agree with his conclusions.[340] Arthur McGarr, a geophysicist with the Earthquake Science Center at the USGS, and Cliff Frohlich, associate director of the Institute for Geophysics at the University of Texas at Austin, both stated that "injection wells, rather than fracturing, can likely trigger quakes."[341] Although these conclusions do not completely eliminate the possibility that there is a connection, it remains to be seen whether such causation in fact exists.[342]

As mentioned above, wastewater reinjection can affect existing geologic stresses that are released in the form of earthquakes.[343] But proving this theory is difficult because of a small data set with only a few discrete events.[344] William Leith, USGS senior science advisor for earthquake and geologic hazards, believes that further "[s]cientific research needs to be done to understand the data on fluid injections and volumes."[345]

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336. *See id.*

337. *See* Matt Smith & Thom Patterson, *Debate Over Fracking, Quakes Gets Louder*, CNN (June 15, 2012, 3:28 PM), http://www.cnn.com/2012/06/15/us/fracking-earthquakes/index.html.

338. *Id.*

339. Jim Fuquay, *Researcher Links Small Quakes in Oklahoma to Injection Wells*, STAR-TELEGRAM (Dec. 6, 2012), http://www.star-telegram.com/2012/12/05/4463996/researcher-links-small-quakes.html (noting that Holland's findings were presented at the American Geophysical Union annual meeting in San Francisco). Fuquay also notes that:

> Quakes have become more frequent in Oklahoma, mostly in the center of the state, which has a history of seismic activity, [and] . . . . included a 5.7-magnitude quake in November 2011, the largest in the state's history. [Holland] did not attribute that quake to oil and gas activity. But other areas of the state with a long history of oil and gas activity haven't seen an increase in earthquakes . . . . The largest quake Holland said he could connect with hydraulic fracturing registered magnitude 2.9, barely enough to be felt. Most were less than a 2. The average time between a quake and hydraulic fracturing was 11 days.

Id.

340. *Id.*

341. *Id.*

342. Smith & Patterson, *supra* note 337.

343. *See id.*

344. Henry Fountain, *Add Quakes to Rumblings Over Gas Rush*, NEW YORK TIMES (Dec. 12, 2011), http://www.nytimes.com/2011/12/13/science/some-blame-hydraulic-fracturing-for-earthquake-epidemic.html?_r=0.

345. *Id.* (internal quotation marks omitted).

In fact, the USGS, which is the federal agency charged with studying and monitoring earthquake activity, "has re-established a project to study induced seismicity in response to the string of suspicious quakes in shale-gas areas."[346]

Earthquakes can occur when fracturing or injecting wastewater into disposal wells causes "shock waves or fluids [to] release strain on a preexisting fault."[347] Thus, "high-pressure fluid can squeeze into and push apart a planar fault, freeing adjacent rock formations to slide past one another."[348] But more research must and will be done on these relationships and, in particular, the relationship between wastewater reinjection and seismicity. In 2010, Congress requested that the National Academy of Science study the seismicity events.[349] According to the report, reinjection of wastewater poses a greater risk of man-made seismic events than fracturing.[350] Other studies, however, have found a stronger connection with hydraulic fracturing.[351] John Armbruster, of the Lamont-Doherty Earth Observatory at Columbia University, has been studying seismic events and hydraulic fracturing in Ohio and is "virtually certain" that wastewater reinjection caused a 4.0 magnitude tremor near Youngstown.[352] Armbruster argues "any disposal well that's been pumping stuff into the ground for months can cause earthquakes."[353] In response to the tremors, Ohio state officials ordered four disposal wells in the area to be closed.[354] Notably, only a small number of perceptible tremors have been reported out of almost 30,000 disposal wells across the country, the strongest of which was equivalent to a 4.8 earthquake.[355]

But there is no general scientific consensus.[356] Frohlich believes "[i]t's almost impossible to say with certainty an earthquake is manmade . . . ."[357] And the National Research Council, an arm of the National Academy of Sciences, which conducted the aforementioned report, found

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346. *Id.*

347. Peter Fairley, *Fracking Quakes Shake the Shale Gas Industry Well Shutdowns Prompted by Fracking-Induced Seismicity May Inspire Technology Tweaks*, MIT TECH. REV. (Jan. 20, 2012), http://www.technologyreview.com/news/426653/fracking-quakes-shake-the-shale-gas-industry/.

348. *Id.*

349. Smith & Patterson, *supra* note 337.

350. *Id.*

351. *See id.*

352. *Id.* (internal quotation marks omitted).

353. *Id.* (internal quotation marks omitted).

354. *Id.* Induced fault slips likely occurred in the Youngstown quake. Fairley, *supra* note 347 (interviewing Thomas Stewart, executive vice president of the Ohio Oil and Gas Association). These induced quakes "are rare events because well operators deliberately avoid drilling near known faults." *Id.* Moreover, the effects of the Youngstown quakes were minimal and likely "hurt no one other than local gas producer D&L Energy, whose well was shut down by state regulators," which resulted in the loss of a $3–$4 million investment. *Id.*

355. *Id.*

356. *See id.*

357. Fuquay, *supra* note 339 (internal quotation marks omitted).

that "[w]hile the general mechanisms that create induced seismic events are well understood, we are currently unable to accurately predict the magnitude or occurrence of such events due to the lack of comprehensive data on complex natural rock systems and the lack of validated predictive models."[358] Although the USGS "acknowledges that increased seismic activity coincides with wastewater injection," it does not conclude that there is "proof of a direct connection."[359] Indeed, the Deputy Secretary of the United States Department of the Interior (DOI), which governs the USGS, stated that "[w]hile it appears likely that the observed seismicity rate changes in the middle part of the United States in recent years are manmade, it remains to be determined if they are related to either changes in production methodologies or to the rate of oil and gas production."[360]

To aid in these research efforts or at the request of concerned surface owners, companies may decide to measure seismic activity by placing monitors near their producing and disposal wells.[361] McGarr proposes an early warning system, which follows "the seismic risk assessment protocol for well-blasting operations employed by geothermal-energy producers."[362] Of course, unless direct causation is established between hydraulic fracturing and seismicity, there can be no resolution of this issue.[363] As

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358. Smith & Patterson, *supra* note 337 (internal quotation marks omitted).

359. *Id.*; *see also* Fuquay, *supra* note 339 (quoting Cliff Frohlich, who notes that "'statistically, you can say injection wells have caused earthquakes,' although there are many injection wells in areas that haven't had earthquakes").

360. Smith & Patterson, *supra* note 337 (internal quotation marks omitted). The author notes that the USGS has presented several papers on this subject. *Id.*; *see, e.g.*, W. L. Ellsworth et al., U.S. Geological Survey, Session at the Seismological Society of America Annual Meeting, Are Seismicity Rate Changes in the Midcontinent Natural or Manmade? (Apr. 18, 2012), *abstract available at* http://www.fossil.energy.gov/programs/gasregulation/authorizations/Orders_Issued_2012/65._Are_ Seismicity_Rate_or_Manmade_.pdf. David Hayes explains the USGS report in his article on the subject. David J. Hayes, Deputy Sec., U.S. Dep't of the Interior, *Is the Recent Increase in Felt Earthquakes in the Central US Natural or Manmade?* (Apr. 11, 2012), http://www.doi.gov/news/ doinews/Is-the-Recent-Increase-in-Felt-Earthquakes-in-the-Central-US-Natural-or-Manmade.cfm. Hayes states that:

> USGS's studies do not suggest that hydraulic fracturing, commonly known as "fracking," causes the increased rate of earthquakes. USGS's scientists have found, however, that at some locations the increase in seismicity coincides with the injection of wastewater in deep disposal wells.
>
> . . . .
>
> Although we cannot eliminate the possibility, there have been no conclusive examples linking wastewater injection activity to triggering of large, major earthquakes even when located near a known fault.

Id.; *see also* Justin Rubinstein, *The 2001-Present Triggered Seismicity Sequence in the Raton Basin of Southern Colorado/Northern New Mexico*, U.S. GEOLOGICAL SURVEY (Dec. 5, 2013, 1:40 PM), http://www.usgs.gov/newsroom/article.asp?ID=3468. The author notes, though, that Rubinstein's research involves the deep injection of wastewater from coalbed methane fields. *Id.*

361. *See* Hayes, *supra* note 360.

362. Fairley, *supra* note 347.

363. *See* Smith & Patterson, *supra* note 337.

even Holland noted in his 2011 report filed with the Oklahoma Geological Survey:

> While the societal impact of understanding whether or not small earthquakes may have been caused by hydraulic-fracturing may be small, it could potentially help us learn more about subsurface properties such as stresses at depth, strength of faults, fluid flow, pressure diffusion, and long term fault and earthquake behaviors of the stable continent. It may also be possible to identify what criteria may affect the likelihood of anthropogenically induced earthquakes and provide oil and gas operators the ability to minimize any adverse affects . . . .[364]

Therefore, in the absence of a direct connection, shale gas development should continue with judicious monitoring, but without geostructural limitation.

IV. THE NEXT GREAT COMPROMISE

"When a broad table is to be made, and the edges of planks do not fit,
the artist takes a little from both, and makes a good joint.
In like manner here, both sides must part with some of their demands."
– Benjamin Franklin[365]

Shale gas development offers an achievable consensus. Without compromise regarding our energy future, we may face a decrease in industrial growth or an increase in environmental harm. Finding this balance between energy and the environment requires shale gas development, but first will require productive dialogue.[366] Although this communication occurs presently in the form of academic debates at Cornell, Duke, Pennsylvania State, and Yale, it needs to move into the larger public arena.[367] Currently, either biased broadcasters or non-governmental organizations with direct or indirect ties to the energy industry or environmental groups transmit most shale gas development media

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364. AUSTIN HOLLAND, OKLA. GEOLOGICAL SURVEY, EXAMINATION OF POSSIBLY INDUCED SEISMICITY FROM HYDRAULIC FRACTURING IN THE EOLA FIELD, GARVIN COUNTY, OKLAHOMA 25 (2011), *available at* http://www.ogs.ou.edu/pubsscanned/openfile/OF1_2011.pdf.

365. *Madison Debates (June 30)*, YALE LAW SCH. LILLIAN GOLDMAN LAW LIBRARY, *available at* http://avalon.law.yale.edu/18th_century/debates_630.asp (last visited Nov. 24, 2013).

366. *See* McKenzie, *supra* note 32 (stating that "[w]hat we need, then, is a pact that keeps the production going while answering the environmental questions").

367. *See* John Daly, *Duke University Study Links Fracking to Ground Water Contamination*, OILPRICE.COM (June 26, 2013, 9:47 PM), http://oilprice.com/Energy/Energy-General/Duke-University-Study-Links-Fracking-to-Ground-Water-Contamination.html; EID Marcellus, *Cornell Hosts Hydraulic Fracturing Debate*, ENERGY IN DEPTH (Nov. 23, 2012, 8:08 PM), http://energyindepth.org/marcellus/cornell-hosts-hydraulic-fracturing-debate/; *Yale Panel to Debate Hydraulic Fracturing*, YALE SCH. OF FORESTRY & ENVTL. STUDIES (Aug. 27, 2012), http://environment.yale.edu/news/article/yale-panel-to-debate-hydraulic-fracturing/.

coverage. Thus, even assuming the information's truth, its origin taints its content and lessens its value. As a result, both supporters and opponents of shale gas development may look askew at any statistics put forth by what is perceived to be the other side.[368]

These dialogical relationships are already forming.[369] In 2010, the partnership between the Environmental Defense Fund (EDF) and Southwestern Energy Corporation, a large shale gas developer, set a goal to create a set of best practice standards for shale development.[370] The EDF formed a similar partnership with the University of Texas and large natural gas producers, such as Anadarko Petroleum, Encana, ExxonMobil subsidiary XTO Energy, Inc., and Pioneer Natural Resources Company, to conduct methane leakage testing.[371] While these smaller partnerships are a good start, the Next Great Compromise may form through an inclusive consortium of energy industry members and trade associations such as the American Petroleum Institute and the American Natural Gas Association; environmental groups such as EDF or the Natural Resources Defense Council; public representatives such as designated surface owners or other affected persons; scholars who would promulgate issues in petroleum engineering, geology, environmental and social sciences, and economic experts; and government groups such as the EPA, DOE, and DOI, which would provide insight into and advice on federal policies and legislation.

Goals of this consortium may include:

- Developing operational best practice standards and regulatory guidance;[372]

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368. *See, e.g.*, Elizabeth Ames Jones, *Clearing the Air on Hydraulic Fracturing Laws in Texas*, FORBES (Dec. 9, 2012, 11:45 AM), http://www.forbes.com/sites/realspin/2012/12/09/clearing-the-air-on-hydraulic-fracturing-laws-in-texas/. Jones states that:

> Recently, a media outlet with a track record of aggressively protecting its own proprietary information published an article that called into question how some contractors have chosen to use this provision since the law became effective in February of this year. The article contained numerous quotes from well-known anti-energy development activists and politicians with long track records opposing responsible development of our nation's bountiful oil and natural gas reserves.

Id.

369. *See id.*

370. Jennifer A. Dlouhy, *Adversaries Try to Heal Fracture Over Hydraulic Fracturing*, HOUS. CHRON. (Oct. 31, 2010), http://www.chron.com/business/energy/article/Adversaries-try-to-heal-fracture-over-hydraulic-1707807.php; Anne C. Mulkern, *Growing in Power, Natural Gas Attracts Enemies*, N.Y. TIMES (Feb. 16, 2011), http://www.nytimes.com/gwire/2011/02/16/16greenwire-growing-in-power-natural-gas-attracts-enemies-92162.html?pagewanted=all.

371. *See What Will It Take to Get Sustained Benefits From Natural Gas?: Understanding the Climate Impacts of Methane Leakage from Natural Gas*, ENVTL. DEF. FUND, http://www.edf.org/methaneleakage (last visited Nov. 24, 2013) (noting that the study is set for completion in January 2013).

372. *See* Dennis C. Stickley, *Expanding Best Practice: The Conundrum of Hydraulic Fracturing*, 12 WYO. L. REV. 321, 333 (2012). The author notes that even George Mitchell, the father of shale gas, has called for stricter regulation. Christopher Helman, *Billionaire Father Of Fracking Says Government*

- Conducting studies to evaluate the effects of shale gas development, such as seismicity and contamination;
- Creating a research and development arm to investigate technologies that aid in the fracturing process with limited use of water and chemicals; and
- Promoting events such as Duke University's recent workshop on hydraulic fracturing, which opened certain sessions to the general public, and the Environmental Protection Agency's public meetings to collect comments on hydraulic fracturing.[373]

But in order to be effective, and before any goals are set, members of this consortium must agree on these basic tenets of any energy policy: (1) energy is a fundamental building block of modern life and is key to sustaining our standard of living, and industrial output and energy demand are only increasing; (2) the attributes of an ideal energy source include abundant source availability, immunity from geopolitical risk, scalability, and rapid deployment using existing or easily-modified infrastructure or technology;[374] and (3) all forms of energy—including renewables—involve trade-offs, and we must, therefore, choose a source or a variety of sources that provide the most benefit with the least impact on human health and the environment. Agreement on these basic premises will allow the parties to form realistic goals instead of arguing over impractical ones. If proponents and opponents of shale gas development establish trust with each other and communicate using one balanced voice, they will be able to effectively influence political legislation and forward the energy-environmental balance. The strength of this consortium will not lie in its members' universal agreement, but rather, in their unified participation and acceptance of a common goal.

V. CONCLUSION

"You cannot compromise unless people talk to you."
– Aung San Suu Kyi[375]

Compromise begins with communication, and effective communication begins with a goal. Here the goal is to promote a fuel source or variety of sources that provide ample, low-cost, and reliable energy to

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Must Step Up Regulation, FORBES (July 19, 2012, 8:29 AM), http://www.forbes.com/sites/christopherhelman/2012/07/19/billionaire-father-of-fracking-says-government-must-step-up-regulation/.

373. *See Duke Workshop*, *supra* note 29, at 248; EPA Public Meetings on Hydraulic Fracturing: July 8, 2010/September 15, 2010 (July 8, 2010), www.epa.gov/hfstudy/all-agendas-093010.pdf (listing meeting agenda topics).

374. *Duke Workshop*, *supra* note 29, at 248.

375. Interview by Christiane Amanpour with Aung San Suu Kyi and Bernard Henry-Levy (Sept. 21, 2012), *transcript available at* http://edition.cnn.com/TRANSCRIPTS/1209/21/ampr.01.html.

Americans, with little impact on human health and the environment. But as with any negotiation, each group must understand the practical limits of the issue. First, there is not currently a perfect source of energy. Each potential fuel source is replete with its own benefits and disadvantages, so the solution entails a balance using risk-reward analysis. Second, a viable energy source may include a portfolio of sources rather than just a single dominant source. Third, no fuel source will be permanent. Just as prehistoric man's technology progressed through the Stone, Bronze, and Iron Ages, so too will his energy sources evolve.

Shale gas is a good compromise. Not only is it abundant, available, and relatively inexpensive, but also, its American origins reduce, if not eliminate, geopolitical risk.[376] Moreover, replacing coal with natural gas reduces environmental harms such as greenhouse gas and particulate emissions. Additional benefits include economic growth at local, state, and national levels; creation of jobs directly in the oil and gas sector; and creation of jobs indirectly in areas such as chemical manufacturing, which relies on low-cost natural gas as a feedstock.[377]

Finally, a successful compromise also relies on a clear medium of communication. The current chaotic channels of information and opinions in newspaper editorials, internet videos, films, and other media outlets do not allow for constructive debate or exchange of material information between groups.[378] As a result of this chaos, misinformation accrues and clouds public perception, which handicaps political will. Hence, the formation of a consortium composed of industry, environmentalists, the public, academics, and government will aid in the public edification regarding shale gas development and its necessity to this country. As the EDF stated:

> [W]e are realists and we recognize that fossil fuels will be around for a while, a long while most likely. And we also recognize that natural gas has some environmental advantages compared to other fossil fuels. . . . But where there's development, the public needs to recognize that some impact is inevitable and the question is how to minimize that impact and be as protective of the environment as reasonably possible.[379]

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376. *See* Daniel Yergin, *The Real Stimulus: Low-Cost Natural Gas*, WALL ST. J., Oct. 23, 2012, at A17.

377. Clifford Krauss & Eric Lipton, *After the Boom in Natural Gas*, N.Y. TIMES, Oct. 20, 2012, at BU Y4.

378. *See, e.g.*, Holman W. Jenkins, Jr., *Good Will Fracking*, WALL ST. J., Dec. 11, 2012, at A17 (referring to the Hollywood film, *Promised Land*, starring Matt Damon); GASLAND, *supra* note 125.

379. *Natural Gas: EDF's Scott Anderson Discusses Fracking Controversy*, E&ETV (Oct. 27, 2010), http://www.eenews.net/tv/videos/1235. Environment & Energy Publishing (E&E) is an online publication covering "environmental and energy policy and markets." *About E&E Publishing*, E&E PUBLISHING, LLC, http://www.eenews.net/eep/learn_more/ (last visited Nov. 24, 2013).

Cooperation and communication will allow us to pursue and achieve the goal of an American energy evolution by responsibly developing shale gas resources without sacrificing our environment, industry, or standard of living. It is time for the Next Great Compromise.