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ASKING THE RIGHT QUESTIONS ABOUT THE FUTURE OF SHALE GAS

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Two roads diverged in a wood, and I—
I took the one less traveled by,
And that has made all the difference.

—Robert Frost[1]

I. INTRODUCTION

Not too long ago, I spoke at a two-day energy conference in Houston. Most of the conference was devoted to energy development all over the world, particularly oil and gas. At the end of the conference, a well-respected professor summarized what had been said and used existing activities to project what the future holds. He spoke not a word about environment or climate change, much less sustainable development. When question time came, I asked him how climate change might affect his projections. "I don't know," he replied. "What do you think?"

This article is an extended answer to his question. It argues that the questions we have been asking about energy—the ones

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1. ROBERT FROST, *The Road Not Taken, in* MOUNTAIN INTERVAL 9 (1916), http://babel.hathitrust.org/cgi/pt?id=hvd.hwxuek;view=1up;seq=2.

that have framed national energy law and policy for decades—are no longer the only relevant questions, and certainly not the best questions. It is increasingly clear that the challenges of sustainable development and climate change can no longer be ignored. These challenges need to frame the way in which energy law and policy decisions are made. Two roads are diverging. One is most traveled. It is based on business-as-usual practices, which by and large are unsustainable, and which lead to an unattractive future. The other is "less traveled by," often simply ignored, and not even fully mapped, but it is based on sustainable practices and offers our only hope of an attractive and sustainable future.

The questions that for decades have guided decision-making on U.S. energy policy are about how to assure cheap, plentiful, and secure energy. Another question is how to achieve basic environmental and public health protection.[2] These questions tend to frame our decisions about energy, and constitute the frame within which the rapid development of shale gas has been placed. These are necessary questions, but they are not sufficient to address challenges that are becoming clearer every year. We thus need to ask better questions. Better questions lead to more useful answers, and thus more effective laws and policies.[3]

Shale gas is a case in point. Beginning about a decade ago, there has been tremendous growth in the extraction of gas from shale through the use of horizontal drilling and hydrofracturing with large volumes of high-pressure water.[4] The effect is that shale strata with little previous economic market value are now the subject of substantial shale gas drilling and production.[5] Unconventional shale gas development, as it is called, has grown rapidly, especially in North America. U.S. production has grown "from 0.3 trillion cubic feet in 2000 to 9.6 trillion cubic feet in 2012."[6] In 2012, shale gas production was 39 percent of total U.S. gas production and 15 percent of total Canadian gas production.[7] While less drilling from shale gas has occurred in other countries, there is intense international interest where recoverable shale gas reserves exist.[8] As this article is being written, gas prices are at a

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2. John C. Dernbach, *U.S. Policy, in* GLOBAL CLIMATE CHANGE AND U.S. LAW 61, 66 (Michael B. Gerrard ed., 2007).

3. MARC K. LANDY, MARC J. ROBERTS & STEPHEN R. THOMAS, THE ENVIRONMENTAL PROTECTION AGENCY: ASKING THE WRONG QUESTIONS (1990).

4. VIKRAM RAO, SHALE GAS: THE PROMISE AND THE PERIL 4–7 (2012).

5. *Id.*

6. U.S. Energy Information Administration, *North America Leads the World in Production of Shale Gas* (Oct. 23, 2013), www.eia.gov/todayinenergy/detail.cfm?id=13491 (last visited Jan. 15, 2016).

7. *Id.*

8. *See, e.g.*, SHALE GAS INTERNATIONAL, www.shalegas.international (last

very low level, and relatively little new drilling is going on.[9] But there is great interest in Pennsylvania and other states in the planning and construction of pipelines to bring gas from existing wells to market, including an international market.[10] An enormous policy and popular literature exists concerning shale gas development.[11]

At the same time, sustainable development has emerged as an approach for reconciling conflicts between development and environmental protection. Sustainable development is a framework for integrating environmental considerations and goals into decisions concerning social and economic development, with the ultimate objective of maintaining and improving human well-being.[12] There is a similarly large body of literature on sustainable development.[13] The sustainable development literature describes, in considerable detail, the ways in which sustainable development has been applied to green building,[14] forestry,[15] agriculture,[16]

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visited Mar. 22, 2016) (international trade publication of shale gas industry).

9. Scott DiSavino, *Big U.S. Shale Field Marcellus Faces Output Drop Due to Low Gas Prices*, REUTERS (May 28, 2015), www.reuters.com/article/natgas-marcellus-production-idUSL1N0YA2LJ20150528.

10. *See, e.g.*, Stephanie Ritenbaugh, *Marcellus Shale Region to See Wave of Large Pipeline Projects*, PITTSBURGH POST-GAZETTE (June 23, 2015), http://powersource.post-gazette.com/powersource/companies/2015/06/23/Marcellus-Shale-region-to-see-wave-of-large-pipeline-projects/stories/201506090010 (explaining that as many as 17 pipeline projects may be constructed in next three years).

11. *See, e.g.*, RUSSELL GOLD, THE BOOM: HOW FRACKING IGNITED THE AMERICAN ENERGY REVOLUTION AND CHANGED THE WORLD (2014); RAO, *supra* note 4; SEAMUS MCGRAW, THE END OF COUNTRY: DISPATCHES FROM THE FRACK ZONE (2011).

12. John C. Dernbach & Federico Cheever, *Sustainable Development and its Discontents*, 4 TRANSNAT'L ENVTL. L. 247, 247 (2015).

13. The author has, for example, edited or coauthored three books assessing sustainable development progress in the United States. JOHN C. DERNBACH ET AL., ACTING AS IF TOMORROW MATTERS: ACCELERATING THE TRANSITION TO SUSTAINABILITY (2012); AGENDA FOR A SUSTAINABLE AMERICA (John C. Dernbach ed., 2009); STUMBLING TOWARD SUSTAINABILITY (John C. Dernbach ed., 2002). For a recent and helpful addition to the sustainable development literature, *see* JEFFREY D. SACHS, THE AGE OF SUSTAINABLE DEVELOPMENT (2015).

14. *E.g.*, ABE KRUGER & CARL SEVILLE, GREEN BUILDING: PRINCIPLES AND PRACTICES IN RESIDENTIAL CONSTRUCTION (2013); THE LAW OF GREEN BUILDINGS: REGULATORY AND LEGAL ISSUES IN DESIGN, CONSTRUCTION, OPERATIONS, AND FINANCING (J. Cullen Howe & Michael B. Gerrard eds., 2010); Keith H. Hirokawa & Aurelia Marina Pohrib, *The Role of Green Building in Climate Change Adaptation, in* RESEARCH HANDBOOK ON CLIMATE ADAPTION LAW 355 (Jonathan Verschuuren ed., 2013).

15. *E.g.*, K.M. REYNOLDS ET AL., SUSTAINABLE FORESTRY: FROM MONITORING AND MODELING TO KNOWLEDGE MANAGEMENT AND POLICY SCIENCE (2007); Federico Cheever & Ward J. Scott, *Sustainable Forestry: Moving from Concept to Consistent Practice, in* AGENDA FOR A SUSTAINABLE

higher education,[17] and communities.[18] Oddly, however, there has been very little discussion about the relationship between shale gas, on one hand, and sustainable development, including climate change, on the other. The most prominent exception may be found in the work of the Center for Sustainable Shale Development, a nongovernmental organization that has certified a small number of companies for their adherence to certain sustainability practices that the Center has developed.[19]

This gap has considerable importance. It means that, except for the little-used certification program run by the Center for Sustainable Shale Development, there is nothing that translates the broad principles of sustainable development into actual practice concerning shale gas. Moreover, while that certification program covers a wide range of practices related to environmental impact, it has little to say about the wide range of social and land use impacts caused by shale gas development. And while it includes practices related to methane emissions from site development and gas production, it does not address the overall role of shale gas development in climate change. If shale gas development is to be truly sustainable, it must fully address all sustainable development issues. Moreover, the many claims made about the positive economic, security, and job creation benefits of shale gas[20] cannot be fully evaluated unless other effects—particularly social and environmental effects—are also evaluated. Professor James May of Widener University Delaware Law School and I have made an effort to fill that void with a recent book, *Shale Gas and the Future of Energy: Law and Policy for Sustainability*.[21] The book includes twelve chapters by sixteen

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AMERICA, *supra* note 13, at 285.

16. NATIONAL RESEARCH COUNCIL, TOWARD SUSTAINABLE AGRICULTURAL SYSTEMS IN THE 21ST CENTURY (2010).

17. Wynn Calder & Julian Dautremont-Smith, *Higher Education: Emerging Laboratories for Inventing a Sustainable Future, in* AGENDA FOR A SUSTAINABLE AMERICA, *supra* note 13, at 93; John C. Dernbach, *The Essential and Growing Role of Legal Education in Achieving Sustainability*, 60 J. LEGAL EDUC. 489 (2011).

18. JEFF SPECK, WALKABLE CITY: HOW DOWNTOWN CAN SAVE AMERICA, ONE STEP AT A TIME (2012); ROBERT H. FREILICH, ROBERT J. SITKOWSKI & SETH D. MENNILLO, FROM SPRAWL TO SUSTAINABILITY: SMART GROWTH, NEW URBANISM, GREEN DEVELOPMENT, AND RENEWABLE ENERGY (2010).

19. Center for Sustainable Shale Development, www.sustainableshale.org/; *News*, Center for Shale Gas Development, www.sustainableshale.org/news/ (showing companies that have received certification) (last visited Jan. 15, 2016).

20. *See e.g.*, Richard J. Pierce, Jr., *Natural Gas Fracking Addresses All of Our Major Problems*, 4 GEO. WASH. J. ENERGY & ENVTL. L. 22 (2013) (summarizing benefits of unconventional gas development).

21. SHALE GAS AND THE FUTURE OF ENERGY: LAW AND POLICY FOR SUSTAINABILITY (John C. Dernbach & James R. May eds., 2016). This book

contributing authors, including not only lawyers and current and former policy makers, but also experts from public health, the social sciences, economics, and other disciplines. As a starting point, the book asks: Is shale gas development sustainable? If not, can law and policy actually make shale gas development sustainable, or are there inherent sustainability issues or problems with shale gas development that cannot be solved by law or policy? The book emphasizes that it is not enough to make *some* effort or progress toward sustainability. The longer we stay primarily committed to fossil fuel energy development, the more expensive and less effective our response is likely to be. Thus, even better questions are (1) can shale gas help accelerate the transition to sustainability, and (2) if so, how? The book focuses on five broad areas relevant to these questions: public health and the environment; community; public participation, public information, and access to justice; governance; and energy and climate change.

This article builds on, and draws from, the energy and climate change aspects of the book; it does not contain a detailed explanation of key findings or conclusions from the entire volume. This article identifies three additional questions that sustainable development would have us answer in making energy policy decisions, using shale gas as a focal point. Sustainable development, in other words, reframes the climate change and energy policy debate in at least three mutually reinforcing ways.

Section II provides the normative lens through which these three new questions emerge. It begins by describing sustainable development, which would redirect the way in which development occurs. Broadly understood, development is a way of improving human wellbeing through economic growth and improved social wellbeing as well as peace and security. As a conceptual model, development is inherently flawed because, by not protecting the environment and the people who depend on it, it tends to adversely affect both. *Sustainable* development, by contrast, would achieve the goals of development and protect the environment as well as those who depend on it. Sustainable development principles and concepts, in turn, are embedded in the United

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grows out of the first national conference in the United States on the confluence of shale gas development and sustainable development, "Marcellus Shale Development and Pennsylvania: What Lessons for Sustainable Energy?," which was held on September 27, 2013, at Widener University School of Law in Harrisburg, Pennsylvania. For a recording of the conference, as well as PowerPoint presentations from the various speakers, *see* WIDENER UNIVERSITY COMMONWEALTH LAW SCHOOL, *Marcellus Shale Development and Pennsylvania: Symposium Takes Comprehensive Look at Marcellus Shale, Sustainable Development and Fracking* (Sept. 30, 2013), http://commonwealth law.widener.edu/marcellusshale2013/ (last visited Nov. 6, 2016).

Nations Framework Convention on Climate Change.[22] The Convention states, as a basic principle: "The Parties have a right to, and should, promote sustainable development."[23] It requires countries to integrate climate change mitigation and adaptation into their decision making.[24] Section II also describes the landmark December 2015 Paris Agreement of the Conference of the Parties to the Framework Convention,[25] in which parties effectively agreed to a goal of net zero greenhouse gas emissions by the second half of this century, based on sustainable development.[26]

Sections III, IV, and V then analyze three typical frames that are used in developing and implementing shale gas laws and policies in light of sustainable development and the Paris Agreement. These sections explain the inadequacy of those frames, and explain how those frames should be replaced by different questions.

Section III explains that a typical frame for shale gas is based on the ostensible greenhouse gas benefits of shale gas. Using gas to produce electricity, the argument goes, produces fewer greenhouse gas emissions than burning coal. But the question should not be whether shale gas is contributing to some degree to a reduction in greenhouse gas emissions. Rather, the question is whether and to what extent the use of gas is consistent with the scale and pace of required greenhouse gas emission reductions. As Section III explains, greenhouse gas reductions to date from use of gas do not begin to compare to the reductions required to avoid catastrophic climate change. While new federal laws to address emissions of greenhouse gas emissions put the United States on a trajectory for achieving that goal over the next decade or so, they do not get the U.S. to that objective.

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22. United Nations Framework Convention on Climate Change, May 9, 1992 (entered into force Mar. 21, 1994), 1771 U.N.T.S. 107, https://unfccc.int/files/essential_background/background_publications_htmlpdf/application/pdf/conveng.pdf [hereinafter *Framework Convention*].

23. *Id.*, art. 3.4.

24. *Id.*, art. 4.2(a).

25. United Nations Framework Convention on Climate Change, *Conference of the Parties,* Decision 1/CP.21 (Adoption of the Paris Agreement) U.N. Doc. FCCC/CP/2015/L.9/Rev.1 (2015), https://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf. Decision 1/CP.21 has two parts, a preamble and an annex. The annex contains the Paris Agreement itself. To avoid confusion with the Paris Agreement, citations to the preamble will refer to Decision 1/CP.21, and citations to the Paris Agreement itself will refer to the Paris Agreement.

26. "Parties aim to reach global peaking of greenhouse gas emissions as soon as possible . . . and to undertake rapid reductions thereafter . . . so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century . . . ." *Id.*, art. 4.1. The "balance" of emissions and removals means net zero emissions.

Section IV addresses a second typical question in energy and climate change policy: how can we produce the energy we need? A better question is: how much energy do we need? Sustainability, in other words, focuses more on energy efficiency and conservation, and would have us answer that question before plunging headlong into shale gas development. The problem, as Section IV explains, is that energy efficiency and conservation have not been deployed to the full extent possible. In fact, the energy available by extracting the remaining energy efficiency opportunities from the economy is greater than the amount of energy available from shale gas. A strengthened national effort to foster energy productivity—which measures how much energy is needed to produce a dollar of GDP—would almost certainly result in much less energy being needed in the first place.

A third and final typical frame for shale gas policy is based on the claim that shale gas produces economic benefits, including not only economic development but also jobs and tax revenue. Here, there is no doubt; economic benefits occur.[27] But as Section V explains, a better question is not about the economic benefits of shale gas standing alone, but also about costs of shale gas and the benefits and costs of alternatives. Environmental regulation of shale gas is intended to reduce or eliminate many of the environmental and social costs of shale gas, but it varies significantly from state to state, and certain legal tools that could be of value have not been fully deployed. Moreover, some impacts—including but not limited to land use and housing—are not covered by environmental regulation. Other laws and policies tend not to adequately address these other issues. Section V also explains that energy efficiency and conservation produce more benefits and have fewer costs than shale gas production. That makes energy efficiency and conservation attractive approaches to reduce greenhouse gas emissions—not only for their climate change benefits, but for their other economic, social, and environmental benefits. Energy efficiency and conservation also impose fewer costs.

As already suggested, these three frames do not exhaust the sustainability issues raised by unconventional shale gas development. Shale gas also raises other sustainability issues, including intergenerational issues such as "boom and bust" cycles as communities experience drilling, production, depletion of the gas resource, further drilling, further production, and ultimate depletion.[28] Our book assesses the adequacy of existing regulatory

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27. *See* Pierce, *supra* note 20.

28. Diana Stares, James McElfish & John Ubinger Jr., *Sustainability and Community Responses to Local Impacts, in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 101.

frameworks from a sustainability perspective and makes recommendations for improving them.[29]

These three frames, however, suggest directions that energy and climate change law and policy need to move for shale gas as well as other fossil fuels. They suggest that shale gas development needs to be nested in a national and international legal and policy framework that is moving rapidly toward net zero carbon emissions. They also suggest the need for an intensified national commitment to energy efficiency and conservation. Finally, they suggest shale gas requires a sophisticated and comprehensive regulatory system to protect the environment and public health as well as a legal and policy framework capable of ensuring both significant social and economic benefits and ensuring that no one is made socially or economically worse off in absolute terms. If shale gas is to be truly sustainable, or be part of a bridge to a sustainable future, it must operate within these parameters.

II. SUSTAINABLE DEVELOPMENT AND THE PARIS AGREEMENT ON CLIMATE CHANGE

Sustainable development—which may be one of the most important ideas to emerge from the 20th century—would redirect the manner in which development occurs. Instead of making progress at the expense of the environment and the people who depend on it, as development does, sustainable development would protect and even restore the environment. The most urgent manifestation of the need for sustainable development is climate change. By providing a structure in which countries can progressively reduce their greenhouse gas emissions, the Paris Agreement also provides a pathway for making significant progress toward sustainable development.

A. Sustainable Development

More than twenty years ago, the United States and the rest of the world decided to change the way in which development occurs. Development, as it has been carried out for decades, is about increasing economic growth as well as social wellbeing. Development also requires a foundation of peace and security. Its ultimate objective is human well-being.[30] Development is no small thing; it is and has been the framework in which progress is measured. Improvements in economic growth, job creation, human

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29. *See infra* notes 178–87 and accompanying text.

30. John C. Dernbach, *Sustainable Development as a Framework for National Governance*, 49 CASE W. RES. L. REV. 1, 9–14 (1998).

health, and education are all evidence of progress. The status of each country is defined in terms of whether it is developed (e.g., United States) or developing (e.g., Peru). What development historically ignores or gives insufficient attention to, however, is environmental protection. As a result, development tends to produce economic and social benefits at the expense of the environment and those who depend on the environment—persons now living as well as future generations.[31]

Across the globe, there is already considerable environmental degradation, poverty, and inequality, as well as growing pressure on the environment and natural resources.[32] By one estimate, the world in 2050 is likely to have two billion more people than at present (growing from 7 billion to 9 billion), global GDP that is four times what we have now, energy consumption that is 80% higher than that at present, and atmospheric concentration of greenhouse gases as high as 685 parts per million[33] (compared to 449 parts per million in 2012).[34]

The increasing costs of development led governments around the world, in 1992, to endorse a modification of development.[35] This modification, called sustainable development, retains the basic elements of development—economic growth and social wellbeing based on peace and security—but adds environmental protection.[36] The iconic definition of sustainable development is "development that meets the needs of the present without compromising the ability of future generations to meet their own needs."[37] The basic idea is that the environment and the people

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31. WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, OUR COMMON FUTURE 28–37 (1987); John C. Dernbach et al., *Sustainability as a Means of Improving Environmental Justice*, 19 J. ENVTL. & SUSTAINABILITY L. (2012).

32. Organization for Economic Cooperation and Development, *OECD Environmental Outlook to 2050: The Consequences of Inaction—Highlights* (2012), www.oecd.org/env/indicators-modelling-outlooks/49846090.pdf.

33. *Id.* at 3 (greenhouse gas concentrations measured in terms of carbon dioxide equivalent).

34. European Environment Agency, *Atmospheric Greenhouse Gas Concentrations*, www.eea.europa.eu/data-and-maps/indicators/atmospheric-greenhouse-gas-concentrations-4/assessment (last visited Jan. 15, 2016).

35. U.N. Conference on Environment and Development (UNCED), *Agenda 21*, U.N. Doc. A/CONF.151/26 (1992), https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf (international strategy for sustainable development); UNCED, *Rio Declaration on Environment and Development*, U.N. Doc. A/CONF.151/5/Rev.1, 31 I.L.M. 874 (1992), www.unep.org/Documents.Multilingual/Default.asp?documentid=78&articleid=1163 (principles for sustainable development).

36. Dernbach, *Sustainable Development as a Framework for National Governance*, *supra* note 30, at 21–29.

37. WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT, *supra* note 31, at 43. For an overview of what occurred at the 1992 U.N. Conference on

who depend on the environment should no longer be the price of progress. Instead, they should benefit from, or at the very least not be harmed by, development. The basic action principle underlying sustainable development is integrated decision-making, which means that development and the environment need to be considered and furthered together.[38] The effect of this approach is not simply to reduce environmental impacts, but to redirect the manner in which development occurs. Sustainable development is now the officially endorsed international approach to maintaining and improving the human condition.[39] This is especially true after the U.N. General Assembly adopted Sustainable Development Goals in 2015 that are intended to guide the manner in which sustainable development occurs.[40]

In principle, sustainable development is preferable to conventional development for at least three reasons—all of which follow from the preceding discussion. To begin with, it is more equitable than conventional development because it does not benefit some people by making other people worse off in absolute terms than they were previously. In addition, it produces a wider range of benefits than conventional development because it includes not only economic and security benefits, but also social and environmental benefits. Finally, sustainable development has fewer costs than conventional development because it is not based on acceptance of harm to people or the environment as part of the price of progress. Because the costs of conventional development blunt its benefits to some degree, and increasingly threaten to outweigh its benefits entirely (e.g., climate change), the conventional development model needs to be replaced. Still, because sustainable development is a relatively new and normative framework, and because it threatens many existing ways of doing business, adoption and implementation have come

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Environment and Development, in which nations first endorsed sustainable development, *see* Dernbach, *supra* note 30, at 21–24.

38. Marie-Claire Cordonier Segger & Ashfaq Khalfan, SUSTAINABLE DEVELOPMENT LAW: PRINCIPLES, PRACTICES, AND PROSPECTS 103 (2004); John C. Dernbach, *Achieving Sustainable Development: The Centrality and Multiple Facets of Integrated Decisionmaking*, 10 IND. J. GLOBAL LEGAL. STUD. 247 (2003).

39. G.A. Res. 70/1, pmbl. & ¶ 2 (Oct. 21, 2015) ("We are determined to ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature.") "We are committed to achieving sustainable development in its three dimensions – economic, social and environmental – in a balanced and integrated manner."; Dernbach & Cheever, *Sustainable Development and its Discontents*, *supra* note 12, at 250 (explaining how sustainable development has become internationally accepted framework for improving human condition).

40. G.A. Res. 70/1, *supra* note 39.

more slowly than one would have hoped.[41] And in many cases, sustainable development has been almost entirely ignored.

There is growing recognition that sustainable development must occur much more quickly. Thus, it is not enough to make *some progress* in improving environmental protection, economic and social development, and peace and security. Extreme poverty is still widespread and environmental conditions around the world continue to deteriorate.[42] Concentrations of greenhouse gases in the atmosphere are rising, and are already at levels that have not been seen for at least 800,000 years.[43] The 2012 United Nations Conference on Sustainable Development thus emphasized the need to "accelerate progress" toward sustainability.[44] Similarly, the parties to the 2012 Conference of the Parties of the United Nations Framework Convention on Climate Change agreed on the importance of "accelerating the reduction of global greenhouse gases emissions."[45]

B. The Paris Agreement

The Paris Agreement is a landmark agreement in international efforts to address climate change. It represents the first time since the Framework Convention on Climate Change was opened for signature in 1992 that all 196 parties have agreed to take actions to reduce their greenhouse gas emissions.[46] The only prior agreement even remotely comparable to the Paris Agreement—the Kyoto Protocol—limited only developed country's emissions.[47]

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41. For assessments of mixed results in two countries, *see* DERNBACH ET AL., ACTING AS IF TOMORROW MATTERS, *supra* note 13 (assessing the United States) and Andrea Ross, SUSTAINABLE DEVELOPMENT LAW IN THE UK: FROM RHETORIC TO REALITY? (2012) (assessing the United Kingdom).

42. UNITED NATIONS ENVIRONMENT PROGRAMME, GLOBAL ENVIRONMENTAL OUTLOOK 5: ENVIRONMENT FOR THE FUTURE WE WANT (2012), www.unep.org/geo/pdfs/geo5/GEO5_report_full_en.pdf.

43. WORKING GROUP I, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS 11 (2013), www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf.

44. United Nations Conference on Sustainable Development, *The Future We Want*, ¶ 19, U.N. Doc. A/CONF.216/16 (June 20–22, 2012), www.uncsd 2012.org/content/documents/814UNCSD%20REPORT%20final%20revs.pdf.

45. U.N. Framework Convention on Climate Change, *Advancing the Durban Platform*, FCCC/CP/2012/8/Add.1 (2012), https://unfccc.int/files/bodies/election_and_membership/application/pdf/decision_2_cp18_adp_bureau.pdf.

46. Joby Warrick & Chris Mooney, *196 Countries Approve Historic Climate Agreement*, WASH. POST (Dec. 12, 2015), www.washingtonpost.com/news/energy-environment/wp/2015/12/12/proposed-historic-climate-pact-nears-final-vote/.

47. Kyoto Protocol to the United Nations Framework Convention on Climate Change, art. 3.1 & Annex B, Dec. 10, 1997, U.N. Doc. FCCC/CP/197/L.7/Add. http://unfccc.int/resource/docs/convkp/kpeng.pdf [hereinafter *Kyoto Protocol*].

The United Nations Framework Convention on Climate Change (Framework Convention) entered into force in 1994, and 196 countries are now parties.[48] The objective of the U.N. Framework Convention on Climate Change is "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."[49] The Framework Convention does what its name suggests; it creates an international framework to address climate change based on mitigation, adaptation, reporting, scientific and technological research, and annual meetings of the conference of the parties.[50] It also requires all parties to establish, implement, and periodically update national programs to mitigate climate change.[51] The Framework Convention does not, however, contain any legally binding agreement to reduce greenhouse gas emissions.

The Framework Convention treats developed and developing countries differently. As its preamble states, developed countries have contributed "the largest share of historical and current global emissions of greenhouse gases."[52] They also, by definition, have greater financial and technological resources. Thus, in ratifying the Framework Convention, developed countries agreed to adopt policies and measures that will demonstrate that they "are taking the lead" in addressing climate change.[53] Still, developed countries agreed only to the "aim" of reducing their greenhouse gas emissions to 1990 levels by 2000.[54]

In December 1997, at their annual meeting in Kyoto, Japan, the parties agreed to a protocol containing binding greenhouse gas emission limits for developed countries.[55] Under the Kyoto Protocol, developed countries agreed to reduce their net greenhouse gas emissions by at least five percent from 1990 levels by 2008–2012.[56] No comparable commitment is included for developing countries. The Protocol contains somewhat different commitments for individual developed countries; the U.S.

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48. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, *Status of Ratification of the Convention*, http://unfccc.int/essential_background/convention/status_of_ratification/items/2631.php (last visited Jan. 16, 2015). There are actually 197 parties—196 countries and an economic integration organization, the European Union. *Id.*

49. Framework Convention, *supra* note 22, art. 2.

50. *Id.*, arts. 4–10.

51. *Id.*, art. 4.1(b).

52. *Id.*, at pmbl.

53. *Id.*, art. 4.2(a).

54. *Id.*, art. 4.2(a) & (b).

55. *Kyoto* Protocol, *supra* note 47.

56. *Id.*, art. 3.1. The Annex I or developed countries also agreed to make "demonstrable progress" by 2005 in meeting their commitments. *Id.*, art. 3.2.

commitment is seven percent below 1990 levels.[57] The U.S., under the second President Bush, repudiated the Kyoto Protocol, citing both economic reasons and the absence of commitments by developing countries, particularly China and India.[58] In contrast, most other developed countries, including those in the European Union, have been implementing the Kyoto Protocol and reducing their greenhouse gas emissions.[59]

A big question left open by the Kyoto Protocol is what to do after 2012, the last year in the 2008–2012 commitment period. The 2012 conference of the parties in Doha, Qatar extended the Kyoto Protocol date to 2020,[60] but that still left open the question of what happens after then. Beginning in 2009, at the conference of the parties in Copenhagen, Denmark, the process has shifted slowly from "top down" commitments by developed countries to "bottom up" commitments by all countries.[61] Under this new approach, each country makes public pledges or commitments, called intended nationally determined contributions (INDCs) prior to the Paris Agreement and nationally determined contributions (NDCs) in the Agreement itself.[62] Just prior to the Paris conference, 178 out of Framework Convention's 196 country parties had submitted

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57. *Id.* at Annex B.

58. *Letter to Members of the Senate on the Kyoto Protocol on Climate Change*, 37 WEEKLY COMP. PRES. DOC. 444 (Mar. 13, 2001), www.gpo.gov/fdsys/pkg/WCPD-2001-03-19/pdf/WCPD-2001-03-19-Pg444-2.pdf.

59. Emissions of the greenhouse gases covered under the Kyoto Protocol declined by 19.8 percent between 1990 and 2013 in the 28 countries of the European Union. EUROSTAT, *Greenhouse Gas Emission Statistics*, http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics (last updated Dec. 15, 2015). A key part of the European approach has been the use of emissions trading, which is authorized by articles 4, 6, and 17 of the *Kyoto Protocol*, *supra* note 47. *See generally,* CLIMATE CHANGE AND EUROPEAN EMISSIONS TRADING: LESSONS FOR THEORY AND PRACTICE (Michael G. Faure & Marjan Peeters, eds., 2008) (describing and analyzing European emissions trading system).

60. United Nations Framework Convention on Climate Change, Report of the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol on its Eighth Session, held in Doha from 26 November to 8 December 2012, Decision 1/CP.8, FCCC/KP/CMP/2012/13/Add.1 (Feb. 28, 2013), http://unfccc.int/resource/docs/2012/cmp8/eng/13a01.pdf. As of October 26, 2016, only 71 of the 144 required instruments of acceptance have been received, and so the Doha Amendment has not yet taken effect. United Nations Framework Convention on Climate Change, Status of the Doha Amendment, http://unfccc.int/kyoto_protocol/doha_amendment/items/7362.php (last visited Nov. 6, 2016).

61. Conference of the Parties of the United Nations Framework Convention on Climate Change, Copenhagen Accord, FCCC/CP/2009/L.7 (Dec. 2009), http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf.

62. United Nations Framework Convention on Climate Change, Intended Nationally Determined Contributions (INDCs), http://unfccc.int/focus/indc_portal/items/8766.php (last visited Jan. 17, 2016).

an INDC, representing 93 percent of the world's greenhouse gas emissions.[63]

Also in the run-up to the Paris conference, the Conference of the Parties translated the Framework Convention's stabilization objective into a maximum permissible surface temperature increase. The most frequently stated goal was 2 °C (or 3.6 degrees Fahrenheit) above preindustrial levels.[64] Parties, it said in 2010, "should take urgent action to meet this long-term goal, consistent with science and on the basis of equity."[65] In addition, the conference stated the importance of "strengthening the long-term global goal on the basis of the best available scientific knowledge, including in relation to a global average temperature rise of 1.5 °C."[66] Closer to Paris, however, the parties had stated the goal in terms of both temperatures. In 2014, for example, the Conference of the Parties expressed the goal in terms of a "likely chance of holding the increase in global average temperature below 2°C or 1.5°C above pre-industrial levels."[67]

The 2°C limit has been translated into a specific carbon "budget"—a numerical limit on all additional emissions, cumulatively, for the rest of the century.[68] The Intergovernmental Panel on Climate Change has concluded that this budget is between 630 and 1,180 gigatons of carbon dioxide equivalent.[69] That range represents the cumulative total of all new emissions of carbon dioxide equivalent between 2011 and 2100.[70] If cumulative emissions do not exceed the figures in that range, the IPCC states,

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63. Gregor Erbach, European Parliamentary Research Service, Negotiating a New UN Climate Agreement: Challenges for the Paris Climate Change Conference 16 (2015), www.europarl.europa.eu/RegData/etudes/IDAN/2015/572794/EPRS_IDA(2015)572794_EN.pdf.

64. United Nations Framework Convention on Climate Change, Report of the Conference of the Parties on its Sixteenth Session, Held in Cancun from 29 November to 10 December 2010, Decision 1/CP.16,¶ 4, FCCC/CP/2010/7/Add.1 (Mar. 15, 2011), http://unfccc.int/resource/docs/2010/cop16/eng/07a01.pdf.

65. *Id.*

66. *Id.* That translates to 2.7 degrees Fahrenheit.

67. United Nations Framework Convention on Climate Change, Report of the Conference of the Parties on its Twentieth Session, Held in Lima from 1 to 14 December 2014, Decision 1/CP.20, FCCC/CP/2014/10/Add.1 (Feb. 2, 2015), http://unfccc.int/resource/docs/2014/cop20/eng/10a01.pdf#page=2. The period of 1861 to 1880 provides a baseline for pre-industrial levels.

68. Fred Pearce, *What Is the Carbon Limit? That Depends Who You Ask*, ENVIRONMENT360 (Nov. 6, 2014), http://e360.yale.edu/feature/what_is_the_carbon_limit_that_depends_who_you_ask/2825/.

69. WORKING GROUP III, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE 431 (2014), http://mitigation2014.org/report/publication/. A gigaton is one billion tons. Carbon dioxide equivalent includes all greenhouses gases measured according to the warming potential of carbon dioxide.

70. *Id.*

it is "likely" that global average temperatures will stay below a 2°C increase.[71] To have a "likely" chance of staying within this budget, IPCC says, global greenhouse gas emissions need to be 40 to 70 percent lower by 2050 and "near zero" gigatons of carbon dioxide equivalent or "below" by 2100.[72] The term "likely"—as used by both the Conference of the Parties and the IPCC—means that the chance of a particular outcome is greater than 66 percent,[73] or two out of three. Other calculations of a carbon budget provide less time to reduce emissions that low.[74]

The Paris Agreement is a framework for keeping global greenhouse gas concentrations within that budget, and appears to somewhat strengthen the level of ambition for doing so. It aims to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels" and "to pursue efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change."[75] The 2014 goal of "holding the increase in global average temperature below 2°C or 1.5°C above pre-industrial levels" suggests that satisfying either of these temperature objectives would be sufficient. The Paris agreement goal of keeping the average temperature "well below 2°C" indicates that simply holding the increase to 2°C is not good enough. The additional commitment to "pursue efforts to limit the temperature increase to 1.5°C" does not constitute a commitment to achieving that goal; it is only a commitment to try. But the Agreement's explicit recognition that achieving the 1.5°C goal "would significantly reduce the risks and impacts of climate change" highlights a reality that was not expressly acknowledged one year earlier: while the Framework Convention is intended to prevent "dangerous anthropogenic interference with the climate system,"[76] there can be substantial adverse effects from climate change

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71. *Id.* at 441. Working Group I reached a slightly different estimate about the budget—1,010 additional gigatons of carbon dioxide equivalent. IPCC WORKING GROUP I, *supra* note 43, at 27. Working Group I used a slightly different methodology and did not use ranges. IPCC WORKING GROUP III, *supra* note 69, at 441.

72. *Id.* at 13.

73. *Id.* at 4 n.2.

74. For example, one paper focuses on the time period between 2000 and 2050, not 2000 and 2100, and calculates carbon budgets to avoid exceeding a 2°C increase based on cumulative emissions in the first half of this century. Malte Meinshausen et al., *Greenhouse-Gas Emission Targets For Limiting Global Warming To 2°C*, 458 NATURE 1158 (2009). Given past and projected emissions, they conclude, "we would exhaust the CO_2 emission budget by 2024, 2027 or 2039, depending on the probability accepted for exceeding 2°C (respectively 20%, 25%, or 50%)." *Id.* at 1159.

75. Paris Agreement, *supra* note 25, art. 2.1(a).

76. Framework Convention, *supra* note 22, art. 2.

before that occurs. That acknowledgement tilts the Paris Agreement's objective somewhat closer to 1.5°C.[77]

As a first step toward reaching this objective, the parties also agreed to "aim to reach global peaking of greenhouse gas emissions as soon as possible, recognizing that peaking will take longer for developing country Parties, and to undertake rapid reductions thereafter."[78] Peaking refers to the fact that globally, and in many countries, greenhouse gas emissions have been increasing on an annual basis. Peaking occurs when the annual increase stops, and every subsequent year brings lower emissions, so that a curve of annual emissions over time shows an upward slope, a peak, and then a downward slope. The rapid reduction is to be accomplished "so as to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century."[79] In other words, at some time between 2051 and 2100, total greenhouse gas emissions are to be reduced to net zero.

The Paris Agreement puts primary responsibility for what happens in particular countries where it has always been—with the countries themselves. This is through the mechanism of nationally determined contributions. The Paris agreement affirmed those commitments and made them central to the global climate change effort.[80]

A key to effective action, a 2015 World Bank report on achieving a zero-carbon future says, is "early action."[81] Early action is prudent, cost-effective, and cheaper, and avoids technological lock-in (e.g., construction of fossil-fuel-based power plants that will likely be in service for 40 or more years).[82]

A major problem—known to the parties before Paris—is that their INDCs, taken together, were not sufficient to put countries on a trajectory toward keeping the average temperature increase below 2°C. In 2015, prior to the conference, both the Organization for Economic Cooperation and Development and the International

77. Although not in the Paris Agreement, the Conference of the Parties invited the Intergovernmental Panel on Climate Change to provide, by 2018, a special report "on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways." Decision 1/CP.21, *supra* note 25, ¶ 21. That report is likely to affect the way in which a 1.5 °C objective is viewed.

78. Paris Agreement, *supra* note 25, art. 4.1.

79. *Id.*

80. *Id.* at arts. 3, 4.2, & 4.3.

81. MARIANNE FAY ET AL., INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT / THE WORLD BANK, DECARBONIZING DEVELOPMENT: THREE STEPS TO A ZERO-CARBON FUTURE 39 (2015), www.worldbank.org/content/dam/Worldbank/document/Climate/dd/decarbonizing-development-report.pdf.

82. *Id.*

Energy Agency issued reports saying that the total emissions reductions from all countries that had thus far submitted INDCs would barely change the world's greenhouse gas emissions trajectory.[83] The Conference of the Parties in Paris noted this emissions gap—between what is needed and what was promised—"with concern."[84]

As economist Nicholas Stern summarizes the available scientific literature, the window for keeping temperatures under 2°C "is still open, but is closing rapidly."[85] A variety of projections based on business-as-usual emissions growth put the world on track for a temperature increase of at least 3.7° to 4.8°C.[86] A 2012 report for the World Bank by the Potsdam Institute for Climate Impact Research and Climate Analytics describes the impact of a 4°C temperature increase by 2100 as disastrous.[87] Such a world, the report said, would be "one of unprecedented heat waves, severe drought, and major floods in many regions, with serious impacts on ecosystems and associated services," and no certainty that adaptation would even be possible.[88]

Thus, what also sets the Paris Agreement apart—and will ultimately determine whether humanity averts or limits the worst effects of climate change—are processes that the agreement puts in place to, among other things, periodically increase national

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83. Organization for Economic Cooperation and Development, *Climate Change Mitigation: Policies and Progress* (summary) (2015), www.oecd-ilibrary.org/sites/9789264238787-sum-en/index.html?itemId=/content/summary/d53d9178-en&mimeType=text/html ("Even if the INDCs and national targets announced to date are fully achieved, the remaining global carbon budget (consistent with a below 2 °C world) will be exhausted by around 2040 unless stronger action is taken."); International Energy Agency, Energy and Climate Change: World Energy Outlook Special Report 12 (2015), www.iea.org/publications/freepublications/publication/WEO2015SpecialReportonEnergyandClimateChange.pdf ("With INDCs submitted so far, and the planned energy policies in countries that have yet to submit, the world's estimated remaining carbon budget consistent with a 50% chance of keeping the rise in temperature below 2 °C is consumed by around 2040 – eight months later than is projected in the absence of INDCs.").

84. Paris Agreement, *supra* note 25, at ¶ 17.

85. NICHOLAS STERN, WHY ARE WE WAITING? THE LOGIC, URGENCY, AND PROMISE OF TACKLING CLIMATE CHANGE 32 (2015).

86. SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK & INSTITUTE FOR SUSTAINABLE DEVELOPMENT AND INTERNATIONAL RELATIONS, PATHWAYS TO DEEP DECARBONIZATION 4 (2014), http://unsdsn.org/wp-content/uploads/2014/09/DDPP_Digit_updated.pdf.

87. INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT/WORLD BANK, TURN DOWN THE HEAT: WHY A 4°C WARMER WORLD MUST BE AVOIDED (2012), www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2015/07/17/090224b0828c33e7/1_0/Rendered/PDF/Turn0down0the00orld0must0be0avoided.pdf.

88. *Id.* at xiii–xiv, xviii.

ambition. These processes should greatly enhance the likelihood that the Paris Agreement will actually work. Beginning in 2020, and every five years afterwards, each country is to "prepare, communicate and maintain successive nationally determined contributions that it intends to achieve."[89] These, of course, are in addition to those that countries already submitted. Each "successive nationally determined contribution" is to "represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition."[90] Beginning in 2023, and every five years afterwards, the Conference of the Parties is to "take stock of the implementation of this Agreement to assess the collective progress towards achieving [its] purpose."[91] The outcome of this "global stocktake" is to "inform Parties in updating and enhancing, in a nationally determined manner, their actions," including enhanced "international cooperation for climate action."[92] Again, the overall objective is net zero greenhouse gas emissions by the second half of the century.[93]

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89. Paris Agreement, *supra* note 25, at arts. 4.2, 4.9; *see also* Decision 1/CP.21, *supra* note 25, at ¶¶ 23, 24.

90. Paris Agreement, supra note 25, art. 4.3.

91. *Id.* at arts. 14.1, 14.2.

92. *Id.*, art. 14.3. At least three other types of provisions are intended to support this ratcheting effort toward greater ambition. First, while financial assistance to developing countries has always been part of the international framework to address climate change, developed countries agreed to increase their level of financial support from previous levels by a nonspecific amount. *Id.*, art. 9.1. Developed countries also agreed to communicate "indicative quantitative and qualitative information" about their financial support to developing countries, including projected future levels of public finance. *Id.*, art. 9.5. Second, the Paris Agreement creates "an enhanced transparency framework for action and support." *Id.*, art. 13.1. This framework is partly to understand what NDCs actually mean and achieve. NDCs from different countries use different assumptions and baselines, and enhancing their comparability is essential. This transparency framework is also needed to better understand what financial contributions developed countries are actually making to developing countries. *Id.*, art. 13.5; Joseph E. Aldy, Evaluating Mitigation Effort: Tools and Institutions for Assessing Nationally Determined Contributions 3 (2015), http://belfercenter.ksg.harvard.edu/files/evaluating-mitigation-effort-aldy_web.pdf (explaining differences in forms of mitigation in 129 NDCs submitted through November 8, 2015). Third, recognizing that "[a]ccelerating, encouraging and enabling innovation is critical for an effective, long-term global response to climate change and promoting economic growth and sustainable development," the agreement creates a Technology Mechanism. Paris Agreement, *supra* note 25, at arts. 10.3, 10.5. The purpose of the mechanism is to strengthen existing efforts to foster technology development and the transfer of technology to developing countries. *Id.* at art 10.4. The "global stocktake" is to consider this and other efforts to support "technology development and transfer for developing country Parties." *Id.* at arts. 10.2, 10.6.

93. *Id.*, art. 4.1.

A significant challenge in implementing the Paris Agreement will be the allocation of the emissions budget among many countries. This allocation should be based on population, historical contribution to global atmospheric greenhouse gas concentrations, development status (developed vs. developing), equity, and other factors. The question of each nation's "fair share" of the budget is both essential and highly contested.[94] Moreover, instead of some kind of *ex ante* allocation based on delineated principles to which every country assents, it now appears that each country will determine how it wants to proceed, and the *de facto* allocation will be the sum total of their greenhouse gas emission reduction commitments over time. That, of course, could create significant problems in meeting the Paris Agreement's carbon budget objective. Whatever decisions individual countries make, it is worth remembering that the Paris Agreement preserves to a significant degree the Framework Convention's orientation toward developed country leadership. That means that the United States, among other developed countries, should strive to reduce its greenhouse gas emissions as rapidly as possible. In other words, the emissions reductions curves for developed countries should be steeper than those for developing countries.

III. QUESTION 1: IS THE USE OF SHALE GAS CONSISTENT WITH THE SCALE AND PACE OF REQUIRED GREENHOUSE GAS EMISSION REDUCTIONS?

As the Paris Agreement makes clear, the world as a whole must reduce its greenhouse gas emissions as rapidly as possible, beginning now. The Agreement provides good news and bad news for shale gas. The good news is that it provides a way for shale gas to be a bridge to a sustainable future. The bad news in the Paris Agreement is that, unless some cost effective means of large scale carbon storage is developed in the relatively near future, the bridge needs to be relatively short. But to work in the United States, the Paris Agreement must be translated into national law and policy.

The argument for the greenhouse benefits of shale gas is based on the claim that the burning of gas involves about half of

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94. DONALD A. BROWN, CLIMATE CHANGE ETHICS: NAVIGATING THE PERFECT MORAL STORM (2012); Fred Pearce, *The Trillion-Ton Cap: Allocating the World's Carbon Emissions*, ENVIRONMENT360 (Oct. 24, 2013), http://e360.yale.edu/feature/the_trillion-ton_cap_allocating_the_worlds_carbon_emissions/2703/.

the greenhouse gas emissions as the burning of coal.[95] There is much evidence to support this claim. According to several life-cycle analyses, unconventional shale gas has lower greenhouse gas emissions than coal when used to produce electricity.[96] In fact, a new combined-cycle natural gas plant that replaces a conventional coal plant emits about one-third of the carbon dioxide that the coal plant emits.[97] Because gas is now cheaper than coal, gas is displacing coal, principally for electricity production; coal production in the United States hit a 30-year low in 2015.[98] The Energy Information Administration has projected that, in 2016, natural gas will exceed coal for electricity generation for the first time.[99] Indeed, while U.S. greenhouse gas emissions in 2013 were 5.9 percent higher than they were in 1990, they peaked in 2007 and have been slightly lower since that time.[100] Of course, the economic recession that began in 2007-2008 played a role in reducing emissions, but so has the replacement of coal by natural gas to produce much electricity.[101] The displacement of coal by gas has also had other benefits, including reduced emissions of nitrogen oxides, sulfur dioxide, and particulates.[102]

Still, according to Don Brown, there are two significant problems.[103] First, methane leakage raises questions about the

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95. Center for Climate and Energy Solutions, *Leveraging Natural Gas to Reduce Greenhouse Gas Emissions* 2 (2013), www.c2es.org/docUploads/leveraging-natural-gas-reduce-ghg-emissions.pdf.

96. *E.g.*, Garvin Heath et al., *Harmonization of Initial Estimates of Shale Gas Life Cycle Greenhouse Gas Emissions for Electric Power Generation*, 111 PROC. NAT'L. ACAD. SCI. E3167 (2014); Andrew Burnham et al., *Life-Cycle Greenhouse Gas Emissions of Shale Gas, Natural Gas, Coal, and Petroleum*, 46 ENVTL. SCI. & TECH. 619 (2012).

97. Daniel P. Schrag, *Is Shale Gas Good for Climate Change?*, 141 DAEDALUS 72, 72 (2012).

98. U.S. Energy Information Administration, *Coal Production and Prices Decline in 2015* (Jan. 8, 2016), www.eia.gov/todayinenergy/detail.cfm?id=24472 (showing that coal production in 2015 was lower than it had been since 1986, and attributing decline to rise in market share of natural gas and renewable energy as well as decline in export market).

99. U.S. Energy Information Administration, *Natural Gas Expected to Surpass Coal in Mix of Fuel Used for U.S. Power Generation in 2016* (Mar. 16, 2016), www.eia.gov/todayinenergy/detail.cfm?id=25392.

100. U.S. ENVIRONMENTAL PROTECTION AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2013 at ES-4 (2015), www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Main-Text.pdf.

101. *Id.* at ES-12.

102. Union of Concerned Scientists, *Environmental Impacts of Natural Gas*, www.ucsusa.org/clean_energy/our-energy-choices/coal-and-other-fossil-fuels/environmental-impacts-of-natural-gas.html#.Vx5__U10yUk (last visited Apr. 25, 2016).

103. The structure of the argument in this section is based on Donald A. Brown, *Is Shale Gas Part of a Sustainable Solution to Climate Change? A*

extent of the greenhouse gas emissions reduction that is being claimed. Natural gas is made up mostly of methane, which is more than 20 times as potent a greenhouse gas as carbon dioxide over a 100-year period.[104] Methane leaks can occur in a variety of ways during gas production, transportation, and use. Understanding the effect of methane leakage involves a difficult methodological question. Recent studies employing varying methodologies have found varying rates of methane leakage from the production and distribution of shale gas.[105] Because of the potency of methane as a greenhouse gas, a relatively small leakage rate would significantly offset the entire apparent greenhouse gas benefit of fuel switching from coal to natural gas. Leaks from gas wells that are no longer in production raise another source of concern.[106]

Measures can be taken to reduce methane leakage, as demonstrated by newly adopted regulations by the U.S. Environmental Protection Agency,[107] state requirements such as those in Colorado,[108] good industry practices, and other programs.[109] In addition, large emitters of greenhouse gases, including methane, are required to annually publish their

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Factual and Ethical Analysis, in SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 271.

104. WORKING GROUP I, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, *supra* note 43, at 58–59.

105. A. R. Brandt et al., *Methane Leaks from North American Natural Gas Systems*, 343 SCIENCE 733 (2014); Dana R. Caulton et al., *Toward a Better Understanding and Quantification of Methane Emissions from Shale Gas Development*, 111 PROC. NATL. ACAD. SCI. 6237 (2014); David T. Allen et al., *Measurements of Methane Emissions at Natural Gas Production Sites in the United States*, 110 PROC. NATL. ACAD. SCI. 17768 (2013); Scot M. Miller et al., *Anthropogenic Emissions of Methane in the United States*, 110 PROC. NATL. ACAD. SCI. 20018 (2013).

In addition, the Environmental Defense Fund commissioned a series of studies to better understand methane emissions from natural gas production and distribution. The findings in these studies generally support the conclusion that methane emissions from gas production and distribution are significant. For an overview of these studies, *see* Environmental Defense Fund, Methane Research: The 16 Study Series (2015), www.edf.org/sites/default/files/methane_studies_fact_sheet.pdf.

106. *See, e.g.*, Charlotte Alter, *The Worst Gas Leak in California's History Isn't Close to Being Fixed*, TIME (Dec. 16, 2015), http://time.com/4149170/california-natural-gas-methane-leak/.

107. 40 C.F.R. pt. 60.

108. Jennifer Oldham, *Colorado First State to Clamp Down on Fracking Methane Pollution*, BLOOMBERG NEWS (Feb. 23, 2014), www.bloomberg.com/news/2014-02-24/colorado-first-state-to-clamp-down-on-fracking-methane-pollution.html.

109. THE WHITE HOUSE, CLIMATE CHANGE ACTION PLAN—STRATEGY TO REDUCE METHANE EMISSIONS (2014), www.whitehouse.gov/sites/default/files/strategy_to_reduce_methane_emissions_2014-03-28_final.pdf.

emissions.[110] Public reporting may help reduce emissions from gas production and distribution. Thus, while natural gas systems were the second largest source of anthropogenic methane emissions in 2013, reported methane emissions from these systems have declined somewhat since 2007.[111] Still, methane leakage offsets the ostensible greenhouse gas benefit of natural gas to some degree.

The second problem with the greenhouse gas benefit of shale gas is that gas is still a fossil fuel. Even if there were no methane leakage, and natural gas produced half of the emissions of coal, the use of gas to replace coal does not, by itself, achieve the level of emissions reduction that is required to meet the greenhouse gas emissions budget.[112] Government greenhouse gas reduction strategies are mistakenly placing undue reliance on gas as a means of reducing emissions, particularly because the annual reductions achieved thus far do not begin to meet the annual reductions required to meet the greenhouse gas reduction budget.[113] The more time passes before carbon dioxide emissions peak and then decline, the steeper the annual reductions must be—from 4-5 percent (peaking date of 2015) to 8 percent (peaking date of 2025).[114] Excluding situations where economic collapse has occurred, there is only one example of a country that achieved annual greenhouse gas reductions of more than four percent.[115] By contrast, the annual changes in U.S. greenhouse gas emissions in 2009-2013 were a mix of increases and decreases.[116] Annual declines from the previous year were in 2009 (-6.5%), 2011 (-1.8%), and 2012 (-3.4%); annual increases were in 2010 (2.6%) and 2013 (2.0%).[117] That indicates a need for the United States and other countries to graduate away from all fossil fuels as quickly as possible.[118] The longer it takes for that to happen, the more severe the annual reductions in greenhouse gas emissions will need to be, making it unlikely that humans will avoid catastrophic climate change.

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110. Mandatory Reporting of Greenhouse Gases, 74 FED. REG. 58, 260 (Oct. 30, 2009) (codified at 40 CFR pts. 86, 87, 89, 90, 94, 98, 1033, 1039, 1042, 1045, 1048, 1051, 1054, & 1065).

111. U.S. ENVIRONMENTAL PROTECTION AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2013, *supra* note 100, at ES-14. Enteric fermentation from domestic livestock—caused by belching or flatulence—was the largest source of methane emissions. *Id.* at ES-13.

112. Brown, *supra* note 103, at 278–83.

113. *Id.*

114. FAY ET AL., *supra* note 81, at 40.

115. *Id.* (citing France when it was developing nuclear power).

116. U.S. ENVIRONMENTAL PROTECTION AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2013, *supra* note 100, at ES-5.

117. *Id.*

118. BROWN, *supra* note 103, at 282–83.

It can be argued that gas is playing a positive role by destabilizing and weakening coal, which contributes more greenhouse gas emissions than any other fossil fuel. There is considerable truth in that argument because gas has displaced coal to some degree. Still, the annual increases and decreases in U.S. greenhouse gas emissions are nowhere near the 4-5 percent annual reductions that are needed, assuming that U.S. greenhouse gas emissions have peaked. Moreover, net zero greenhouse gas emissions and significant use of gas cannot be reconciled unless there is considerable success in carbon removal from the atmosphere or long-term carbon storage. At present, all approaches to carbon removal or negative carbon emissions have significant limitations.[119] Thus, while gas is playing a role in reducing greenhouse gas emissions, the continued production and use of gas is constrained by the greenhouse gas budget—if that budget is honored.

The INDC submitted by the United States in 2015 prior to the Paris conference commits the U.S. "to achieve an economy-wide target of reducing its greenhouse gas emissions by 26%-28% below its 2005 level in 2025."[120] This commitment is based principally on strengthened fuel economy standards for motor vehicles and trucks, strengthened and broadened energy efficiency standards for appliances and equipment, and greenhouse gas limitations for electric generating facilities.[121]

The federal government has adopted increasingly stringent fuel economy and greenhouse gas emission limitations for motor vehicles and trucks. In 2010, EPA and the Department of Transportation adopted a final regulation increasing CAFE standards for light-duty motor vehicles to a combined average emissions level of 250 grams of carbon dioxide per mile by 2016, or 35.5 miles per gallon if manufacturers meet them entirely with fuel efficiency improvements.[122] Then, in 2012, EPA and DOT issued further rules for passenger cars, light-duty trucks and

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119. Pete Smith et al., *Biophysical and Economic Limits to Negative CO2 Emissions*, 6 NATURE CLIMATE CHANGE 42, 49 (Jan. 2016) (There is no negative emission technology or combination of technologies that could be implemented to achieve the 2 degree C goal "without significant impact on either land, energy, water, nutrient, albedo, or cost" and so the primary approach must be to "immediately and aggressively reduce greenhouse gas emissions.").

120. United States, Cover Note, INDC [Intended Nationally Determined Contribution], and Accompanying Information (2015), www4.unfccc.int/submissions/INDC/Published%20Documents/United%20States%20of%20America/1/U.S.%20Cover%20Note%20INDC%20and%20Accompanying%20Information.pdf.

121. *Id.* at 4–5.

122. 75 Fed. Reg. 25, 324 (May 7, 2010) (codified at 40 C.F.R. pts. 85, 86 & 600; 49 C.F.R. pts. 531, 533 & 536).

medium-duty passenger vehicles for model years 2017-2025.[123] The final standards are projected to result in an average industry fleet wide level of 163 grams/mile of carbon dioxide in model year 2025, which is equivalent to 54.5 miles per gallon if achieved exclusively through fuel economy improvements.[124] EPA and DOT have also adopted first-ever regulations to reduce greenhouse gas emissions and improve fuel efficiency of medium- and heavy-duty trucks.[125]

The Department of Energy has adopted and strengthened energy efficiency standards for a wide variety of products, including new refrigerators, air conditioners, clothes washers, and furnaces.[126] The Department of Energy has also adopted efficiency standards for electric motors and a variety of other equipment.[127] Taken together, these standards cover "more than 60 products, representing about 90% of home energy use, 60% of commercial building energy use, and approximately 30% of industrial energy use."[128] The Energy Star appliance labeling program, which is based on voluntary targets that are 10-25% more efficient than applicable standards,[129] provides additional reductions of greenhouse gas emissions.[130] Finally, EPA's Clean Power Plan, finalized in August 2015, would reduce greenhouse gases from electric generating facilities by 32% from 2005 levels by 2030.[131]

These and other efforts help put the U.S. on a path to deep decarbonization.[132] It "is technically feasible for the U.S. to reduce

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123. 77 Fed. Reg. 62, 624 (Oct. 15, 2012) (codified at 40 C.F.R. pts. 85, 86 & 600).

124. 77 Fed. Reg. 62, 627.

125. 76 Fed. Reg. 57, 106 (Sept. 15, 2011) (codified at 40 C.F.R. pts. 85, 86, 600, and others).

126. 10 C.F.R. § 430.32.

127. 10 C.F.R. pt. 431.

128. U.S. Department of Energy, Saving Energy and Money with Appliance and Equipment Standards in the United States (2015), http://energy.gov/sites/prod/files/2015/07/f24/Appliance%20and%20Equipment%20Standards%20Fact%20Sheet%207-21-15.pdf.

129. U.S. Government Accountability Office, Energy Star Program: Covert Testing Shows the Energy Star Program Certification Process Is Vulnerable to Fraud and Abuse 1 (2010), www.gao.gov/new.items/d10470.pdf.

130. U.S. Environmental Protection Agency, Energy Star® Overview of 2014 Achievements (2015), www.energystar.gov/ia/partners/publications/pubdocs/Overview%20of%20Achievements_508Compliant.pdf.

131. Carbon Pollution Emission Guidelines for Existing Stationary Sources: Electric Utility Generating Units; Final Rule, 80 Fed. Reg. 64, 661 (Oct. 23, 2015), www.gpo.gov/fdsys/pkg/FR-2015-10-23/pdf/2015-22842.pdf. On February 9, 2016, the U.S. Supreme Court issued a stay of the Clean Power Plan. *West Virginia v. EPA*, 136 S. Ct. 1000 (2016). The Court issued this stay even though the U.S. Court of the Appeals for the District of Columbia Circuit, where petitions for review of the rulemaking were pending, had not yet heard oral argument.

132. United States, Cover Note, INDC, *supra* note 120, at 1-2.

[carbon dioxide] emissions from fossil fuel combustion" by 85 percent from 1990 levels by 2050, which is "an order of magnitude decrease in per capita emissions compared to 2010."[133] If the U.S. did that, it would reduce its overall greenhouse gas emissions by 80 percent below 1990 levels by 2050.[134]

Except for the Clean Power Plan, however, there is no federal legal mechanism to prod further improvement after 2025, much less achieve these more ambitious goals. By contrast, the American Clean Energy and Security Act (ACES, or the Waxman-Markey bill, after its sponsors, Reps. Henry Waxman and Edward Markey), which passed the House of Representatives in 2009, would have established a cap-and-trade system to reduce greenhouse gas emissions from covered sources 17% below 2005 levels by 2020 and 83% below 2005 levels by 2050.[135] Because greenhouse gas emissions in 2005 were 16.6 % greater than those in 1990, the goal of an 83% percent reduction by 2050 is less ambitious than an 80 percent reduction by 1990.[136] Still, ACES would have created a domestic legal framework for reducing emissions that continued to 2050.

The Paris Agreement may nonetheless prompt a series of continuing reductions and commensurate laws in the United States and other countries. These processes are different from the kinds of obligations that are familiar in environmental law–obligations, for example, to reduce greenhouse gas emissions by a certain amount by a certain date. Rather, these processes may be understood in terms of reflexive law and governance. Reflexive approaches are not substantive rules: they improve the capacity of governmental institutions and other entities to learn about

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133. SUSTAINABLE DEVELOPMENT SOLUTIONS NETWORK & INSTITUTE FOR SUSTAINABLE DEVELOPMENT AND INTERNATIONAL RELATIONS, *supra* note 86, at 204.

134. JAMES H. WILLIAMS ET AL., ENERGY AND ENVIRONMENTAL ECONOMICS, INC. (E3), LAWRENCE BERKELEY NATIONAL LABORATORY (LBNL) & PACIFIC NORTHWEST NATIONAL LABORATORY (PNNL), PATHWAYS TO DEEP DECARBONIZATION IN THE UNITED STATES xiii (2014), http://unsdsn.org/wp-content/uploads/2014/09/US-Deep-Decarbonization-Report.pdf.

135. American Clean Energy and Security Act, H.R. 2454, 111th Cong. § 304(a) & (b) (2009). The bill was passed by the House of Representatives on June 26, 2009, but was not passed by the Senate. GOVTRACK.US, H.R. 2454 (111th): American Clean Energy and Security Act of 2009, www.govtrack.us/congress/votes/111-2009/h477.

136. U.S. greenhouse gas emissions in 2005 were 7,350.2 million metric tons of carbon dioxide equivalent, compared to 6,301.1 in 1990. U.S. ENVIRONMENTAL PROTECTION AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2013, *supra* note 100, at ES17-ES19. The 2005 baseline, in other words, is 16.6 percent higher than the 1990 baseline. Thus, emissions reductions from the 2005 baseline are not as great as those from the 1990 baseline.

themselves and their actions.[137] They can provide information to government agencies and institutions on the effectiveness and impacts of particular laws and policies, which can then be used to modify those laws and policies.[138] They can also prod governments and others to improve their practices without being overly prescriptive.[139]

The Paris Agreement is based on reflexive governance at the national and international level. As already noted, every five years beginning in 2015, every country is to submit nationally determined contributions that "represent a progression beyond the Party's then current nationally determined contribution and reflect its highest possible ambition."[140] Every five years beginning in 2023, the Conference of the Parties is to "take stock of the implementation of this Agreement to assess the collective progress towards achieving" its purpose."[141] These requirements should encourage or prod governments, including the United States, to be more ambitious over time, without being prescriptive about what they should do. These requirements also will provide information about what other governments are actually doing, as well information about the effectiveness and impacts of particular laws and policies. This information can then be used to modify laws and policies. In addition, because this information will be public, governments are more likely to honestly and openly share what they are doing, and be more responsive to the views of nongovernmental organizations and businesses as well as the public in general. These outcomes are more likely because every country agreed to the ambitious goals toward which they are aimed.

The Paris Agreement thus means that national greenhouse gas emission laws and policies, including those in the United States, are likely to become more ambitious over time. The displacement of coal by natural gas appears to have some value for at least a limited period, and is likely inevitable in any case for both economic and regulatory reasons. But to achieve net zero greenhouse gas emissions, gas will need to be substantially displaced by energy efficiency and conservation as well as renewable energy—unless, as stated above, there is a dramatic breakthrough in carbon storage or removal. The required scale and

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137. Sanford E. Gaines, *Reflexive Law as a Legal Paradigm for Sustainable Development*, 10 BUFF. ENVTL. L.J. 1, 22 (2002–2003).

138. René Kemp et al., *Governance for Sustainable Development: Moving from Theory to Practice*, 8 INT. J. SUSTAINABLE DEV. 12, 23–26 (2005).

139. Eric W. Orts, *Reflexive Environmental Law*, 89 NW. U. L. REV. 1227, 1311–13 (1995).

140. Paris Agreement, *supra* note 25, art. 4.3.

141. *Id.* at arts. 14.1, 14.2.

scope of required emissions reductions, in turn, should influence investment in shale gas development and production. As Celeste Hammond has explained, "climate change is an area where asking the 'right' questions can add value, including the value of not doing the transaction at all."[142] The zero net emissions objective, for example, could have a substantial effect on return on shale gas investment as well as on a shale gas lender's ability to recoup an investment over the length of a loan.

To be consistent with the scale and pace of required greenhouse gas reductions, then, the production and use of shale gas must be nested in ambitious national and international energy and climate change laws. These laws would assure that shale gas is a bridge fuel to a sustainable future, and does not delay or divert from that objective. While the Paris Agreement provides a structure for the adoption and implementation of appropriate laws in the U.S. and other countries, some but not all of the legal structure to do that job is in place.

IV. QUESTION 2: HOW MUCH ENERGY DO WE NEED?

The dominant perspective on energy is on the supply side: "we always think we need to find and then use more energy, but we almost always assume that the efficiency resources are used up and unavailable."[143] Shale gas, in this context, is simply another source of the energy we need. A better question is about how much energy we need. More specifically, how much additional efficiency can we extract from the economy compared to the amount of shale gas that can be produced? In the "larger sustainability context, energy efficiency is likely to be seen as a much better strategy for the ongoing development of the U.S. economy than shale gas production."[144] Sustainable development and the Paris Agreement underscore both the urgency and attractiveness of accelerating progress in energy efficiency and conservation.

No energy policy choices available to the United States are as attractive and necessary as energy efficiency and conservation. Energy efficiency involves doing the same amount of work, or producing the same amount of goods or services, with less

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142. Celeste Hammond, *The Evolving Role for Transactional Attorneys Responding to Client Needs in Adapting to Climate Change*, 47 J. MARSHALL L. REV. 543, 546 (2013–2014).

143. John A. "Skip" Laitner, The Sustainability Imperative of the Surprisingly Big Energy Efficiency Resource, *in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 253, 257.

144. *Id.* at 256.

energy.[145] Energy conservation is a broader term; it involves using less energy, regardless of the whether energy efficiency has changed.[146] Energy efficiency and conservation provide environmental benefits, to be sure; the gallon of gas or the kilowatt of electricity that is not used is the cleanest of all. That unused gallon or kilowatt, moreover, is also the cheapest of all. Even though energy efficiency often involves additional up-front investment, savings from efficiency provide a return on that investment and often exceed it.

Energy efficiency and conservation also are the most effective and sustainable approaches to addressing climate change. Energy related greenhouse gas emissions are responsible for the great majority of global greenhouse gas emissions.[147] In addition, 78 percent of the total global greenhouse gas emissions increase between 1970 and 2010 was due to carbon dioxide emissions from fossil fuel combustion and industrial processes.[148] Energy efficiency and conservation provide more economic, social, environmental, and security benefits (e.g., reduced energy costs, lower pollution, economic development, job creation, less vulnerability to supply disruption), and fewer costs, than any means of energy production.[149]

To be sure, U.S. energy intensity (energy consumption per dollar of GDP) continues to improve, signifying some progress in energy efficiency. Between 1980 and 2014, energy intensity in the U.S. improved by 50 percent, falling from 12.1 thousand BTUs (or British Thermal Units) per dollar to 6.1 thousand BTUs.[150] Put differently, while U.S. gross domestic product increased by 149 percent during that period, U.S. energy use increased by only 26 percent.[151] About 60 percent of this improvement was due to improvements in energy efficiency, while the rest was due to shifts in the U.S. economy away from energy intensive activities such as heavy manufacturing. This improvement resulted in savings of

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145. NATIONAL ENERGY POLICY DEVELOPMENT GROUP, NATIONAL ENERGY POLICY 1-3 (2001), www.wtrg.com/EnergyReport/National-Energy-Policy.pdf.

146. *Id.*

147. IPCC WORKING GROUP III, *supra* note 69, at 354–55.

148. *Id.* at 6.

149. International Energy Agency, Capturing the Multiple Benefits of Energy Efficiency (2014), www.iea.org/Textbase/npsum/MultipleBenefits2014SUM.pdf; DIANA FARRELL ET AL., MCKINSEY GLOBAL INSTITUTE, THE CASE FOR INVESTING IN ENERGY PRODUCTIVITY 8, 21-30 (2008), www.un.org/ga/president/62/ThematicDebates/gpicc/mgi.pdf; International Energy Agency, World Energy Outlook 2006 43 (2006).

150. STEVEN NADEL, NEAL ELLIOTT AND THERESE LANGER, AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY, ENERGY EFFICIENCY IN THE UNITED STATES: 35 YEARS AND COUNTING iv (2015), www.ourenergypolicy.org/wp-content/uploads/2015/07/e1502.pdf.

151. *Id.*

$800 billion in 2014 to individuals and businesses, or about $2,500 per capita.[152] The average annual decline in energy intensity during this period was two percent.[153] In no small part because of legally required improvements in energy efficiency for motor vehicles, trucks, appliances and industrial equipment, the Energy Information Administration projected in 2015 that U.S. energy intensity will decline at a faster pace—an average annual rate of 2.3%—between 2013 and 2040.[154]

Still, according to the International Energy Agency, only about one-third of the energy efficiency potential of the industry, transportation, power generation, and buildings sectors has been tapped.[155] Approximately twice as much, or two-thirds, of the long-term economic energy efficiency of these sectors, remains untapped.[156] Even in the United States, considerable potential exists for increased improvement in energy efficiency and conservation. Skip Laitner uses data from several different sources to compare the potential availability of energy from energy efficiency, shale gas, and renewable energy (from electricity sources only), using a common metric of trillion cubic feet (TCF).[157] He concludes that the untapped potential of energy efficiency is about 1,400 TCF, compared to 900 TCF for shale gas and 600 TCF equivalent for renewable energy.[158] Other calculations also conclude that there is significant untapped energy efficiency and energy conservation potential in the U.S. economy.[159]

Several types of legal and policy mechanisms are available for using energy efficiency and conservation to drive deep reductions in greenhouse gas emissions. A starting point might be reframing energy efficiency and conservation—which connote sacrifice to many—to energy productivity. Energy productivity, which measures how much energy is needed to produce a dollar of GDP, may provide a more positive understanding of the importance of energy efficiency and conservation.[160] Beyond that, existing energy

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152. *Id.*

153. *Id.* at x.

154. U.S. ENERGY INFORMATION ADMINISTRATION, ANNUAL ENERGY OUTLOOK 2015 WITH PROJECTIONS TO 2040 at 17 (2015), www.eia.gov/forecasts/aeo/pdf/0383(2015).pdf.

155. International Energy Agency, Capturing the Multiple Benefits of Energy Efficiency*, supra* note 149, at 19.

156. *Id.*

157. Laitner, *supra* note 143, at 262.

158. *Id.*

159. *See, e.g.*, HANNAH CHOI GRANADE ET AL., MCKINSEY & CO., UNLOCKING ENERGY EFFICIENCY IN THE U.S. ECONOMY iii (2009), www.greenbuildinglawblog.com/uploads/file/mckinseyUS_energy_efficiency_full_report.pdf (estimating that an ambitious energy effort could reduce projected U.S. energy demand by 23% by 2020).

160. Farrell et al., *supra* note 149, at 7–8. Energy productivity could

and environmental laws privilege incumbent players (e.g., utilities) and existing facilities (coal-fired power plants) in a variety of ways, and have made it harder for newer entrants (e.g., energy efficiency, renewable energy) to compete.[161] Within many sectors and contexts, moreover, incentives are misaligned, so that the person with the ability to achieve greater energy efficiency (e.g., landlord) is frequently not the person who pays the energy bills (e.g., tenant). Laitner advocates law changes that "even the playing field," enabling energy efficiency to "compete effectively and produce more positive outcomes."[162] It is often argued that energy efficiency policy will backfire by, for example, inducing people to drive their fuel efficient cars more and offsetting the efficiency gain. There is no empirical evidence for the backfire hypothesis.[163] Instead, the "total microeconomic rebound is, in most cases, on the order of 20 to 40 percent."[164]

V. QUESTION 3: HOW DO THE BENEFITS OF SHALE GAS COMPARE WITH ITS COSTS AND THE BENEFITS AND COSTS OF ALTERNATIVES?

A final unhelpful frame is based on the economic benefits of shale gas development, including not only economic development but also jobs and tax revenue. A better question is not about the economic benefits of shale gas standing alone, but about the economic benefits of shale gas compared to its costs and risks. A careful examination of both the benefits and the costs yields a different assessment than an assessment of the benefits alone. Moreover, an assessment of the benefits and costs of shale gas, standing alone, is not as helpful as a comparative assessment of shale gas and alternatives, including renewable energy and energy efficiency. Laitner explains that "energy efficiency behaviors and investments can drive significantly greater economic, environmental, and social benefits than reliance on either

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deliver at least half of the emissions reductions needed to keep global temperatures below two degrees C, and could generate energy savings of as much as $900 billion annually by 2020. *Id.* at 8.

161. Laitner, *supra* note 143, at 268 ("[t]he array of incentives now provided for conventional energy resources are significantly larger than those offered for energy efficiency and renewable energy technologies.") (citations omitted).

162. *Id.* at 270.

163. Kenneth Gillingham, David Rapson & Gernot Wagner, *The Rebound Effect and Energy Efficiency Policy*, 10 REV. ENVTL. ECON. & POL'Y, 68 (2016), www.econ.ucdavis.edu/faculty/dsrapson/Rebound_Effect_GRW.pdf.

164. *Id.* This figure, moreover, does not take into account gains in human wellbeing or induced innovation and productivity growth from an energy efficiency policy. *Id.*

conventional or unconventional energy resources such as shale gas."[165]

Shale gas development presents a variety of costs and risks. Among the most prominent are water quality degradation and reduced water availability for consumers.[166] Other prominent risks include not only the climate change effects of methane releases, which were discussed above, but also seismic effects from drilling and effects of underground disposal of fracturing fluids.[167] Understanding these risks requires an understanding of what unconventional gas development entails. Industry representatives often use the term "fracking" narrowly to refer to the use of high-pressure water and explosives to fracture the shale. On the other hand, the public tends to understand "fracking" to refer to the entire unconventional gas development process in ways not limited to hydrofracturing. While industry representatives may be accurate in claiming a lack of "documented cases" of groundwater contamination from hydrofracturing, groundwater and well water contamination from unconventional gas development are well documented.[168] "Faulty casing and cementing cause most well integrity problems"[169] because they lead to migration into groundwater of gas, hydrofracturing fluids, or flowback water from gas production that may include salts and radioactive material.

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165. Laitner, *supra* note 143, at 256.

166. ALAN KRUPNICK, HAL GORDON & SHEILA OLMSTEAD, PATHWAYS TO DIALOGUE: WHAT THE EXPERTS SAY ABOUT THE ENVIRONMENTAL RISKS OF SHALE GAS DEVELOPMENT 18 (2013), www.rff.org/files/sharepoint/WorkImages/Download/RFF-Rpt-PathwaystoDialogue_FullReport.pdf.

167. Maria Gallucci, *Oklahoma Earthquakes 2015: Tremors Rise as Oklahoma Officials Struggle to Stem Fracking Wastewater Flow*, INTL. BUS. TIMES (Oct. 13, 2015), www.ibtimes.com/oklahoma-earthquakes-2015-tremors-rise-oklahoma-officials-struggle-stem-fracking-2138124; *Ohio Announces Tougher Permit Conditions for Drilling Activities Near Faults and Areas of Seismic Activity*, OHIO DEP'T OF NAT. RESOURCES (Apr. 11, 2014), www2.ohiodnr.gov/news/post/ohio-announces-tougher-permit-conditions-for-drilling-activities-near-faults-and-areas-of-seismic-activity.

168. *See, e.g.*, Anthony R. Ingraffea et al., *Assessment and Risk Analysis of Casing and Cement Impairment in Oil and Gas Wells in Pennsylvania, 2000–2012*, 111 PROC. NAT'L ACAD. SCI. 10955 (2014); Thomas H. Darrah et al., *Noble Gases Identify the Mechanisms of Fugitive Gas Contamination in Drinking Water Wells Overlying the Marcellus and Barnett Shales*, 111 PROC. NAT'L ACAD. SCI. 14076 (2014); Laura Legere, *DEP Releases Updated Details on Water Contamination Near Drilling Sites*, PITTSBURGH POST-GAZETTE (Sept. 9, 2014), http://powersource.post-gazette.com/powersource/policy-powersource/2014/09/09/DEP-releases-details-on-water-contamination/stories/201409090010; Avner Vengosh et al., *A Critical Review of the Risks to Water Resources from Unconventional Shale Gas Development and Hydraulic Fracturing in the United States*, 48 ENVTL. SCI. & TECH. 8334 (2014).

169. Robert B. Jackson, *The Integrity of Oil and Gas Wells*, 111 PROC. NAT'L ACAD. SCI. 10902, 10902 (2014).

Unconventional gas development also uses considerable amounts of water. Water availability is particularly a problem in the upper reaches of streams and waterways, where surface water withdrawals are more likely to have adverse effects on aquatic life.[170] In areas that have relatively little rainfall, the use of water for hydrofracturing can also create or contribute to conflicts over scarce supplies.[171]

Almost nothing is known about potential public health hazards from shale gas development, including not only toxic chemicals and pollutants, but also waste, noise, workplace injuries, and community stress.[172] "Despite broad public concern, no comprehensive population-based studies of the public health effects of unconventional natural gas operations exist."[173]

There is considerable variation among states in the regulation of environmental and public health effects of shale gas. Resources for the Future issued a report in 2013 that compared 25 separate aspects of shale gas regulation in 31 states with actual or potential shale gas production.[174] It found wide variation among states, including those pertaining to cementing, well diameter, and thickness of boring pipes; the buffer distance between operational well pads and neighboring residences, commercial districts, schools and hospitals, and water supplies; and limitations on hours of operation, noise, and traffic patterns.[175]

A variety of impacts are not addressed by state regulation, and many require local regulation, particularly of land use. Development of shale gas can have profound effects on

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170. Thomas W. Beauduy, *Water Resources Management & Shale Gas Development in the Susquehanna River Basin: The Lessons Thus Far*, paper presented at Widener University Law School conference, Marcellus Shale Development and Pennsylvania: What Lessons for Sustainable Energy?, Harrisburg PA, Sept. 27, 2013, www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwiEy-TDqYzLAhXrsIMKHcafDTMQFggcMAA&url=http%3A%2F%2Fcommonwealthlaw.widener.edu%2Ffiles%2Fresources%2Fbeauduywaterresourcessusquehanna092713.ppt&usg=AFQjCNFHnvwzD7xA215oa2fmmPo8luCYTQ.

171. Jean-Philippe Nicot & Bridget R. Scanlon, *Water Use for Shale-Gas Production in Texas, U.S.,* 46 ENVTL. SCI. & TECH. 3580 (2012).

172. Lynn Goldman, *Hydrofracking: Potential Health Hazards*, paper presented at Widener University Law School conference, Marcellus Shale Development and Pennsylvania: What Lessons for Sustainable Energy?, Harrisburg PA, Sept. 27, 2013.

173. J. L. Adgate, B. D. Goldstein & L. M. McKenzie, *Potential Public Health Hazards, Exposures and Health Effects from Unconventional Natural Gas Development*, 48 ENVTL. SCI. & TECH. 8307 (2014).

174. NATHAN RICHARDSON ET AL., THE STATE OF STATE SHALE GAS REGULATION 1 (2013), www.rff.org/files/sharepoint/WorkImages/Download/RFF-Rpt-StateofStateRegs_Report.pdf.

175. *Id.* at 18.

communities.[176] More than 15.3 million people live "within a mile of a well that has been drilled since 2000. That is more people than live in Michigan or New York City."[177] Many of the worst environmental and public health impacts occur because various shale gas facilities and activities, including drilling rigs, compressor stations, and wastewater impoundments, are located too close to homes, farms, schools, and water resources. Other impacts include those on housing. Shortages occur during the boom times, and its negative effects "fall heaviest on those whose housing situation was most at risk prior to the Marcellus industry growth, namely the non-working poor, seniors, the disabled and, newly, the working poor."[178]

The question about costs of shale gas and alternatives leads to answers indicating the value of several different types of laws and policies. One approach would reduce the adverse impacts of shale gas development by, for example, strengthening state regulation to improve the way that information about shale gas effects is managed and used,[179] improving the public's ability to participate in government decision making concerning shale gas,[180] requiring a public health impact assessment before shale gas development occurs,[181] requiring companies to account in one place for all of the costs of using water and chemicals for hydrofracturing,[182] or creating a presumption in favor of disclosure

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176. Kim Sorvig, *What to Do When the Drillers Come to Town*, PLANNING, Aug./Sept. 2014, at 14 (describing challenges to local government of shale gas drilling, and stressing importance of advance planning by municipalities to ameliorate its effects).

177. Russell Gold & Tom McGinty, *Energy Boom Puts Wells in America's Backyards*, WALL ST. J. (Oct. 25, 2013), www.wsj.com/articles/SB10001424052702303672404579149432365326304.

178. Jonathan Williamson & Bonita Kolb, *Sustainable Housing in Rural Communities Affected by Shale Gas Development, in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 81, 83.

179. David B. Spence, *Regulating Shale Gas Production for Sustainability: The Federalism Questions, in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 189, 190–91.

180. Kenneth T. Kristl, *Public Participation and Sustainability: How Pennsylvania's Shale Gas Program Thwarts Sustainable Outcomes, in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 125; Jill Morgan, *Sustainability and Stakeholder Participation: Shale Gas Extraction in the United Kingdom, in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 143, 145.

181. Pamela Ko & Patricia Salkin, *Sustainable Drilling Through Health Impact Assessment: Understanding and Planning for Public Health Impacts, in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 33.

182. John H. Quigley, *Requiring Full-cost Accounting for Environmental and Social Impacts in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 52, 56.

of the names of the chemicals used in hydrofracturing.[183] Greater public involvement and more comprehensive planning and decision making for land use and housing are also needed.[184] The sheer complexity and difficulty of getting the entire regulatory and legal structure right is considerable, and raises questions about whether other countries where shale gas is being seriously considered, such as South Africa and New Zealand, can develop the capacity to properly regulate shale gas.[185]

More broadly, we need a national dialogue on which mix of different energy resources is likely to ensure the most positive set of economic, environmental, and social outcomes.[186] That is, we need to discuss not the merits of shale gas standing alone, but the merits of shale gas in comparison to other choices. In particular, "[e]nergy efficiency has the potential to make a much greater contribution to the economy than shale gas, and can produce greater benefits."[187] These benefits, which include economic development, job creation, and lower levels of sulfur dioxide, particulates, and other health-damaging pollutants, are more likely to be experienced directly and immediately than reductions in greenhouse gas emissions. These other benefits, in other words, are essential to attracting the political support needed to address climate change. This dialogue—based on sustainable development—can thus play a significant role in accelerating the reduction of greenhouse gas emissions under the Paris Agreement.

VI. CONCLUSION

This article suggests that policy makers and others need to ask 1) whether the use of shale gas is consistent with the scale and pace of required greenhouse gas emissions, 2) how much energy we need, and 3) how the benefits of shale gas compare with the costs and benefits of alternatives. These three questions put the challenge and immediacy of addressing climate change squarely in front of us, rather than treating climate change as a distant issue

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183. Bernard D. Goldstein, *Relevance of Transparency to Sustainability and to Pennsylvania's Shale Gas Legislation, in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 165.

184. Stares, McElfish & Ubinger, *Sustainability and Community Responses to Local Impacts*, *supra* note 28, at 101; Williamson & Kolb, *supra* note 178.

185. Jan Glazewski, *Sustainable Development and Proposed Shale Gas Extraction in South Africa: Prospects and Challenges, in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 209; Trevor Daya-Winterbottom, *Sustainable Management of Onshore Recovery of Unconventional Gas in New Zealand in* SHALE GAS AND THE FUTURE OF ENERGY, *supra* note 21, at 230.

186. Laitner, *supra* note 143, at 268.

187. *Id.* at 261.

at the margins of our consciousness. The costs of getting climate change wrong are enormous, and there is abundant economic analysis that the costs of ignoring climate change are much greater than the costs of addressing it.[188] Sustainable development offers a framework for responding to this challenge in a way that maximizes economic, social, environmental, and even security benefits. As this article has attempted to show, these questions mark the divergence of two roads—the business-as-usual road and the road to a sustainable future. While the latter is now "the one less traveled by," taking it "will make all the difference."

188. *See supra* notes 85–88 and accompanying text.