A BRIDGE TOO FAR: BUILDING OFF-RAMPS ON THE SHALE GAS SUPERHIGHWAY

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A BRIDGE TOO FAR: BUILDING OFF-RAMPS ON THE SHALE GAS SUPERHIGHWAY

PATRICK PARENTEAU* AND ABIGAIL BARNES**

Owing to past neglect, in the face of the plainest warnings, we have entered upon a period of danger . . . . The era of procrastination, of half measures, of soothing and baffling expedience of delays, is coming to its close. In its place we are entering a period of consequences . . . . We cannot avoid this period, we are in it now . . . .”

Winston Churchill, November 12, 1936, House of Commons

I think we may be going a bridge too far.

British Lieutenant-General Frederick Browning to Field Marshall Bernard Montgomery before the failed attempt to breach the German lines in 1944[1]

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I. INTRODUCTION

Energy policy in the United States is at a decisive crossroads. In the past five years, the nation's energy landscape has witnessed incredible change as previously nonviable reserves of unconventional gas have made their way to market. Energy experts predict that natural gas will serve as a foundation fuel for the twenty-first century global economy[2] and act as a bridge to a new and more climate friendly energy sector.[3] This influx of natural gas raises important questions about the role of gas in the coming decades and its impact on the future of energy and the planet's climate.

At the same time, the pace of climate change is accelerating: 2012 was officially the hottest year on record in the continental United States, continuing a trend of increasing temperatures over the past 132 years.[4] The previous temperature record, set in 1998, was shattered last year by a full degree Fahrenheit. Though natural variability played a role, many scientists believe that anthropogenic greenhouse gases are responsible for this striking increase. Scientists also warned that 2012 was probably a foretaste of things to come, as continued warming increases the likelihood of heat extremes and other calamities.[5]

This is the reality of climate change. Unlike the obvious threat of a madman bent on global domination—the danger that Churchill warned of—global warming poses a more insidious and profound threat.

Meeting the challenges of climate change and providing reliable energy to a global population approaching nine billion in 2050 will require unprecedented collaborative action by governments across the globe. There is mounting evidence that climate change is already having a dramatic impact on weather patterns, human communities, and natural systems. In some cases, the very survival of nations hinges on a global plan to reduce greenhouse gas ("GHG") emissions, and paramount to limiting temperature rise is controlling cumulative emissions—or the total amount we dump into the atmosphere in the coming decades.[6]

The enormous task of "decarbonizing" the national and global economies suggests that any delay to a large-scale transition to a GHG-free energy model could accompany significant environmental and economic consequences.[7] To have any chance at hitting the target of 450 parts per million ("ppm") of CO_2 in the at-

2. Daniel Yergin & Robert Ineson, *America's Natural Gas Revolution*, WALL ST. J. (Nov. 2, 2009), http://online.wsj.com/article/SB10001424052748703399204574507440795971268.html.

3. Dominic Contreras, *Natural Gas as a Bridge to the Future*, HARVARD U., BELFER CENTER FOR SCI. AND INT'L AFF. (Apr. 11, 2012) http://belfercenter.ksg.harvard.edu/publication/21924/natural_gas_as_a_bridge_to_the_future.html.

4. *NASA Finds 2012 Sustained Long-Term Climate Warming Trend*, NASA (Jan. 15, 2013), http://www.nasa.gov/topics/earth/features/2012-temps.html.

5. *Id.*

6. David Roberts, *The Brutal Logic of Climate Change*, GRIST (Dec. 6, 2011), http://grist.org/climate-change/2011-12-05-the-brutal-logic-of-climate-change/.

7. According to a recent report by Price Waterhouse Cooper, the world must quadruple the current rate of decarburization "even to have a reasonable prospect of getting to a 4°C scenario." PWC, LOW CARBON ECONOMY INDEX 2012, TOO LATE FOR TWO DEGREES? (2012), *available at* http://www.pwc.com/en_GX/gx/low-carbon-economy-index/assets/pwc-low-carbon-economy-index-2012.pdf. The report contains this sobering warning: "We have passed a critical threshold—not once since 1950 has the world achieved that rate of decarbonisation in a single year, but the task now confronting us is to achieve it for 39 consecutive years." *Id.*

mosphere, global emissions must peak as soon as possible and begin a steady descent on the order of three to four percent per year.[8] Meeting the more ambitious 350 ppm target recommended by Dr. James Hansen —which the world has already surpassed—would require an even more heroic effort.[9]

These efforts could be stymied by the recent breakthrough advances in hydraulic fracturing (fracking) technologies, which have unlocked huge deposits of natural gas in ancient shale deposits. These reserves are being developed at breakneck speed, which is driving down costs. In April 2012, natural gas prices hit an historic low selling for less than two dollars per million British thermal unit ("Btu").[10] Gas companies are also losing money due to a surplus of gas on the market.[11] This glut prompted billionaire Texas oilman T. Boone Pickens to advise the industry to "shut her down" or temper the natural gas frenzy until prices rebounded.[12] Although inventories have waned in the past eight months, the United States Energy Information Administration ("EIA") projects that gas prices will remain below four dollars through 2018.[13]

In certain respects, this surge of natural gas has benefited the environment and public health. Low natural gas prices have dramatically altered the energy mix in the electricity sector, particularly with respect to coal—the dirtiest fuel that imposes the highest social costs.[14] One result of displacing all of this coal is that United States carbon emissions are, for now at least, the lowest they have been in twenty years.[15] Historically, coal supplied almost half of the nation's electricity.[16] Yet as of April, 2012, natural gas and coal were virtually tied, with each providing thirty-two percent of total generation.[17] Dozens of existing coal plants have been shuttered,[18] and over a hundred new plants have been cancelled.[19] In addition to cheap natural gas, other factors have contributed to this remarkable turnabout: a sluggish

8. Joe Romm, *How the World Can Stabilize at 350 to 450 ppm: The Full Global Warming Solution*, CLIMATE PROGRESS (Mar., 26 2009), http://thinkprogress.org/climate/2009/03/26/203849/ full-global-warming-solution-350-450-ppm-technologies-efficiency-renewables/.

9. *See Understanding 350*, 350.ORG, http://www.350.org/en/node/48 (last visited Mar. 13, 2013).

10. *Henry Hub Gulf Coast Natural Gas Spot Price*, U.S ENERGY INFO. ADMIN. (Jan. 16, 2013), http://www.eia.gov/dnav/ng/hist/rngwhhdM.htm.

11. Clifford Krauss & Eric Lipton, *After the Boom in Natural Gas*, N.Y. TIMES (Oct. 20, 2012), http://www.nytimes.com/2012/10/21/business/energy-environment/in-a-natural-gas-glut-big-winners-and-losers.html?pagewanted=all.

12. *Id.*

13. *Annual Energy Outlook 2013, Early Release Overview*, U.S. ENERGY INFO. ADMIN.. (Dec. 5, 2012), http://www.eia.gov/forecasts/aeo/er/early_prices.cfm.

14. According to a major study by the Harvard School of Medicine: "The economic, health and environmental impacts associated with extraction, transportation, processing, and combustion cost the U.S. public between a third to over half a trillion dollars annually." *Explore the True Cost of Coal*, HARVARD SCH. OF PUB. HEALTH (July 1, 2012), http://chge.med.harvard.edu/resource/explore-true-costs-coal.

15. *Today in Energy*, U.S. ENERGY INFO. ADMIN. (Aug. 1, 2012), http://www.eia.gov/todayinenergy/detail.cfm?id=7350#tabs_co2emissions-1.

16. Guy Raz & Lauren Silverman, *Miners Weather the Slow Burn of Coal's Demise*, NPR (July 14, 2012), http://www.npr.org/2012/07/14/156784701/miners-weather-the-slow-burn-of-coals-demise.

17. *Today in Energy*, U.S. ENERGY INFO. ADMIN. (July 6, 2012), http://www.eia.gov/todayinenergy/detail.cfm?id=6990.

18. *Tracking New Coal Fired Power Plants*, NAT'L ENERGY TECH. LAB. (Jan. 13, 2012), http://www.netl.doe.gov/coal/refshelf/ncp.pdf.

19. *What happened to the 151 proposed coal plants?*, SOURCEWATCH (Feb. 12, 2013), http://www.sourcewatch.org/index.php/What_happened_to_the_151_proposed_coal_plants%3F.

economy,[20] rising costs of steel and cement,[21] more stringent air quality regulations,[22] and a banner year for renewables.[23] For example, nearly half of new United States power capacity in 2012 was renewable.[24]

The claim that a natural gas surge will ultimately provide a net benefit for the environment, however, rests on shaky ground.[25] For one, although coal use in the United States has declined, the foreign export market is increasing, and much of this coal is instead being burned in Europe and Asia.[26] This is the classic "whack a mole" problem. The broader question is whether unconventional gas is truly a "bridge fuel" to a carbon neutral future, or a detour that risks irreversible and potentially catastrophic consequences for this century. This article argues that, unless specific steps ("off-ramps") are taken to offset the "path dependency" nature of investment in unconventional gas recovery, the fracking boom threatens to undermine climate mitigation strategies and squander what may be the last chance to achieve climate stability this century.

It is inevitable that gas from shale and other sources will play a role in meeting future national and global energy needs—the question is what kind of a role. Gas offers undeniable environmental advantages over coal, but it also poses an obstacle to improving energy efficiency and scaling up renewable sources such as solar and wind—necessary energy sources to achieve climate stabilization targets. Unless specific actions are taken to ensure that life cycle emissions from shale gas

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20. The growth rate has averaged less than two percent per year for the past four years. Nelson Schwartz, *U.S. Growth Rate Picks Up to 2%*, N.Y. TIMES (Oct. 26, 2012), http://www.nytimes.com/2012/10/27/business/economy/us-economy-grew-at-2-rate-in-3rd-quarter.html?pagewanted=all.

21. *Impacts of Rising Construction and Equipment Costs on Energy Industries*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/oiaf/aeo/otheranalysis/cecei.html (last visited Jan. 16, 2013).

22. *See, e.g.*, *Revisions to National Ambient Air Quality Standards for Particle Pollution*, EPA (Dec. 19, 2012), http://www.epa.gov/apti/video/20121219pmnaaq s/presentation.pdf (discussing more stringent revisions to the National Ambient Air Quality Standards for Particle pollution); *Mercury Air Toxic Standards: Regulatory Actions*, EPA, http://www.epa.gov/mats/actions.html (last visited Jan. 16, 2013) (proposing updates to the Mercury Air Toxic Standards). Combined, these rules will add significant cost to coal-fired electricity while saving lives and generating net economic benefits from reduced health care costs.

23. "Total global investment in renewables (excluding large hydro) last year was a record $257 billion, an increase of 17 percent from the previous year. According to the UNEP report, renewable power (excluding large hydro) accounted for 44% of new generation capacity added worldwide in 2011, up from 34% in 2010. The U.S. saw a 57 percent increase in investment in renewable energy in 2011, adding up to $51 billion (which nearly tied with China which ranked first at $52 billion." Rachel Cleetus, *New Reports Show 2011 was a Banner Year for Renewable Energy*, UNION OF CONCERNED SCIENTISTS, http://blog.ucsusa.org/new-reports-show-2011-was-a-banner-year-for-renewable-energy (last visited Apr. 13, 2013).

24. FED. ENERGY REG. COMM'N, OFFICE OF ENERGY PROJECTS ENERGY INFRASTRUCTURE UPDATE FOR DECEMBER 2012, 2012, *available at* http://www.ferc.gov/legal/staff-reports/dec-2012-energy-infrastructure.pdf

25. Shakeb Afsah & Kendal Salcito, *Shale Gas and the Fairytale of its CO2 Reductions*, CO2 SCORECARD (Aug. 7, 2012), http://www.co2scorecard.org/home/researchitem/24 ("Nearly 90% of the cuts in CO_2 emissions were caused by (1) the decline in petroleum use in the transportation sector, (2) displacement of coal by mostly non-price factors and (3) its replacement by wind, hydro and other renewables.").

26. *Europe's Energy Policy Delivers the Worst of All Possible Worlds*, THE ECONOMIST (Jan. 5, 2013), http://www.economist.com/news/briefing/21569039-europes-energy-policy-delivers-worst-all-possible-worlds-unwelcome-renaissance ("As American utilities shifted into gas, American coal miners had to look for new markets . . . European purchases of American coal rose by a third in the first six months of 2012.").

are minimized and, even more important, that it does not delay the rapid conversion to renewables, the fracking boom may prove to be a bust for the planet.

The starting point for this analysis is an unflinching look at the stark realities of climate change and disconcerting energy trends, both of which support a renewables-based energy model for the United States.

This article then proceeds to address four questions: (1) whether methane leakage is offsetting the CO_2 reduction benefits of switching from coal to gas; (2) whether methane leakages can be further reduced through more robust use of EPA's Clean Air Act (CAA) authority; (3) whether "cheap gas" will discourage efficiency and impede renewables; and (4) what policies (off-ramps) are needed to avoid a carbon lock-in from a new natural gas infrastructure? We argue that for natural gas to be a useful component of a broader climate mitigation strategy, it must be accompanied by policies explicitly designed to ensure renewable competitiveness. To accomplish this, we propose four off-ramp policies: (1) adopting a progressive carbon tax; (2) leveling the playing field for gas and renewables; (3) ramping up cost-effective energy efficiency measures; and (4) integrating gas and renewables as complementary strategies.

II. CONFRONTING THE FIERCE REALITY OF NOW

It may not have been the Mayan Apocalypse, but 2012 will go down as a year of unprecedented weather extremes and profound changes in global ecosystems. On the storm front last year, the United States was left bruised and battered. Super Storm Sandy, the largest Atlantic hurricane on record, wreaked havoc on the East Coast in October, killing 130 people, knocking out power to over eight million customers, flooding much of the N.Y.C. subway system, and causing over sixty billion dollars in damages.[27] Scientists suggested that warming oceans and rising sea levels were partly to blame for the severity of the storm's damage.[28] Sandy follows on the heels of other devastating storms and weather events, including tropical storm Irene in September 2011, and the worst drought since the great Dust Bowl era, which caused upwards of twenty billion dollars in crop and livestock losses. There was also the recent "derecho," or string of severe thunderstorms, which swept across the East Coast in June.[29] The record-breaking temperatures on the south side of the storm triggered unusually strong winds, leaving many cities blindsided by the damage that ensued.[30]

This year has also marked one of record-setting temperatures, countering the claims of some who insist that global warming has "stopped."[31] A staggering

27. Associated Press, *Superstorm Sandy Deaths, Damage And Magnitude: What We Know One Month Later*, HUFFINGTON POST (Nov. 29, 2012), http://www.huffingtonpost.com/2012/11/29/superstorm-hurricane-sandy-deaths-2012_n_2209217.html.

28. Associated Press, *Hurricane Sandy Damage Partly Caused by Climate Change, Scientists Say*, HUFFINGTON POST, (Nov. 6, 2012), http://www.huffingtonpost.com/2012/11/06/hurricane-damage-climate-change_n_2081960.html.

29. *Id.*

30. *Id.*

31. Peter Gleick, *Global Warming has Stopped? How to Fool People Using "CherryPicked" Climate Data*, FORBES (Feb. 5, 2012), *available at* http://www.forbes.com/sites/petergleick/2012/02/05/global-warming-has-stopped-how-to-fool-people-using-cherry-picked-climate-data/.

34,008 daily record-highs were set at weather stations across the country, compared with only 6,664 record-lows.[32] The extreme heat also fueled a year of fires. Last year was the third worst fire season in United States history, with wildfires scorching 9.2 million acres—an area larger than the state of Maryland.[33]

In large part because of these extreme weather events, the United States led the world in disaster losses last year. Nearly all the world's economic damage from storms, drought, fire and earthquakes was centered in the United States as it experienced the highest temperatures ever recorded.[34] According to Munich Re, a global reinsurance company, more than ninety percent of insured losses worldwide occurred in the United States—well above the thirty-year average of sixty-five percent.[35] These losses added up to one of the most expensive weather damage years on record.[36]

Harder to see, but equally troubling, is the dramatic loss of volume of Artic ice. Artic sea ice shrank to a record low since scientists began to measure it with satellites in 1979,[37] and some scientists are predicting that the Arctic will be nearly ice free in the summer within the next ten years.[38] The ice sheet is about half of what it was in 2000.[39] This coincides with a record low for snow cover in the Northern Hemisphere in June.[40] Warming in the Arctic is more than twice the global average.[41] The probability that this level of melting is due solely to natural variability is less than 0.1%.[42]

Likewise, the Greenland ice sheet is also experiencing unprecedented warming. In July, the ice sheet underwent the most widespread melt on record, covering

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32. Justin Gillis, *Not Even Close: 2012 Was Hottest Ever in U.S.*, NY TIMES, Jan. 8, 2013, http://www.nytimes.com/2013/01/09/science/earth/2012-was-hottest-year-ever-in-us.html?_r=0.

33. Jeff Masters, *The Exceptional U.S. Wildfire Season of 2012*, DR. JEFF MASTERS' WUNDERBLOG, (Dec. 31, 2012, 5:11 PM), http://www.wunderground.com/blog/JeffMasters/comment.html? entrynum=2320.

34. *North America Most Affected by Increase in Weather-Related Natural Catastrophes*, MUNICH RE, http://www.munichre.com/en/media_relations/press_releases/2012/2012_10_17_press_release.aspx (last visited Mar. 16, 2013).

35. *Id.*

36. *Id.*

37. D. Perovich et al., *Sea Ice*, NOAA ARCTIC REPORT CARD (Nov. 11, 2012), http://www.arctic.noaa.gov/reportcard/sea_ice.html. The Executive Summary states: "Large changes in multiple indicators are affecting climate and ecosystems, and, combined, these changes provide strong evidence of the momentum that has developed in the Arctic environmental system due to the impacts of a persistent warming trend that began over 30 years ago." *Id.*

38. Maslowski et al., *The Future of Arctic Sea Ice*, 40 ANNUAL REV. OF EARTH AND PLANETARY SCI. 625–54 (2012), *available at* http://www.annualreviews.org/doi/pdf/10.1146/annurev-earth-042711-105345.

39. Jeff Masters, *Half of the Polar Ice Cap is Missing: Arctic Sea Ice Hits a New Record Low*, DR. JEFF MASTERS' WUNDERBLOG (Sept. 6, 2012), http://www.wunderground.com/blog/JeffMasters/article.html?entrynum=2222.

40. *Record Low Spring Snow Cover in Northern Hemisphere 2012*, NOAA CLIMATE PORTAL (Dec. 12, 2012), http://www.climatewatch.noaa.gov/image/2012/record-low-spring-snow-cover-in-northern-hemisphere-2012.

41. SUSAN JOY HASSOL, IMPACTS OF A WARMING ARCTIC: ARCTIC CLIMATE IMPACT ASSESSMENT 33 (2004), *available at* http://amap.no/workdocs/index.cfm?action=getfile&dirsub=%2FACIA%2Foverview&filename=ArcticImpacts.pdf&CFID=649&CF TOKEN=15F3DE85-E0DC-DBDE-0D96D6BA2B92F579&sort=default.

42. Vinnikov et al., *Global Warming and Northern Hemisphere Sea Ice Extent*, 286 SCIENCE 3 (Dec. 1999), *available at* http://www.sciencemag.org/content/286/5446/1934.full.

about ninety-seven percent of the ice sheet on a single day.[43] Although Greenland has experienced substantial melting in the geologic past, scientists find the recent pattern of extreme melting cause for serious concern.[44] The accelerating melt of this vast frozen repository of fresh water is the wild card in scientific projections of how much and how fast sea levels will rise in coming decades.[45] Similarly, warming in the West Antarctic ice sheet is three times faster than the global average, fueled mainly by increasing ocean temperatures, and raising further concerns about the future contribution of Antarctica to sea level rise.[46]

Arctic permafrost is melting faster than predicted, releasing both carbon and methane into the atmosphere. As this paper highlights, because methane is so much more potent than carbon, especially in the short term, the implications of methane release, even at modest levels, could prove disastrous for climate stabilization targets.[47] Permafrost also contains a staggering 1.5 trillion tons of frozen carbon—about twice as much carbon as contained in the atmosphere.[48] At current warming rates, eleven feet of permafrost could melt this century.[49] Scientists warn of a dangerous tipping point that could send the climate on "autopilot."[50] Remarkably, these events follow a relatively modest average global temperature increase of 0.8°C,[51] suggesting that the climate system may be more sensitive than previously thought. Miscalculations are not surprising given the complexities of climate systems. Climate models are unable to account for numerous positive feedback loops, such as the loss of albedo in the Arctic and the melting permafrost.[52] Consequently, IPCC reports, including the forthcoming fifth assessment, consistently understate the effects of anthropogenic global warming.[53]

43. Steve Cole, *Satellites See Unprecedented Greenland Ice Sheet Surface Melt*, NASA (July 24, 2012), http://www.nasa.gov/home/hqnews/2012/jul/HQ_12-249_Greenland_Ice_Sheet_Melt.html.

44. Joe Romm, *Is Recent Greenland Ice Sheet Melting 'Unprecedented'? Absolutely. Is It 'Worrisome'? You Bet It Is,* CLIMATE PROGRESS BLOG, (Jul. 26, 2012), 8:51 PM), http://thinkprogress.org/climate/2012/07/26/591381/is-recent-greenland-ice-sheet-melting-unprecedented-absolutely-is-it-worrisome-you-bet-it-is/. In commenting on this summer's record Greenland melt Dr. Michael Mann, author of the famous hockey stick graph, said, "It's absolutely worrisome. Some of the statements that scientists have made on this are a classic example of scientific reticence, understating to some extent what we know." *Id.*

45. *Id.*

46. David H. Bromwich et al., *West Antarctica Warming More Than Expected*, ATMOS NEWS (Dec. 13, 2012), http://www2.ucar.edu/atmosnews/news/8570/west-antarctica-warming-more-expected.

47. Michael Slezak, *Arctic Permafrost is Melting Faster than Predicted*, NEW SCIENTIST: ENV'T (Nov. 28, 2012), http://www.newscientist.com/article/dn22549-arctic-permafrost-is-melting-faster-than-predicted.html.

48. *So Many Amplifying Methane Feedbacks, So Little Time to Stop Them All*, THINKPROGESS: CLIMATE PROGESS BLOG, (Aug. 17, 2009), http://thinkprogress.org/climate/2009/08/17/204508/ positive-methane-feedbacks-permafrost-tundra-methane-hydrates/.

49. David Lawrence, *A Projection of Severe Near-Surface Permafrost Degradation During the 21st Century*, GEOPHYSICAL RESEARCH LETTERS VOL. 32, L24401 (2005), *available at* http://cires.colorado.edu/~aslater/PAPERS/2005GL025080.pdf.

50. DeConto et al., *Past Extreme Warming Events Linked to Massive Carbon Release from Thawing Permafrost*, 484 NATURE 87–91 (Apr. 5, 2012).

51. *Global Temperature*, EARTH POL'Y INST., http://www.earth-policy.org/indicators/C51/ (last visited Mar. 7, 2013).

52. *Policy Implications of Melting Permafrost*, UNITED NATIONS ENV'T PROGRAM (2011), *available at* http://www.unep.org/pdf/permafrost.pdf.

53. *Id.*

The changes that have already occurred, and those looming on the horizon, are essentially irreversible within human time frames.[54] Scientists are increasingly concerned that we may be approaching, or may have already passed, certain "tipping points" that could elicit a cascade warming effect and trigger "abrupt climate change."[55] The melting of the permafrost, the release of methane clathrates from the oceans, and the drying of the Amazon are among the most serious threats to accelerating the rate of warming.[56]

Temperature is not the only concern. Ocean acidification from absorption of atmospheric CO_2 poses a serious threat to the marine ecosystem. Oceans are acidifying ten times faster than at any time in the past 300 million years, according to the latest studies.[57] One study found that ocean acidification is increasing faster than what preceded a mass extinction event fifty-five million years ago.[58] Acidification can affect many marine organisms, but especially those that build their shells and skeletons from calcium carbonate, such as corals, oysters, clams, mussels, snails, and phytoplankton and zooplankton, the tiny plants and animals that form the base of the marine food web. Adaptation is not an option for this problem. To avoid potentially catastrophic loss of marine life carbon emissions must cease as soon as possible.

In the Copenhagen Accord, over 100 nations pledged to hold global warming to 2°C (corresponding to about 450 ppm atmospheric concentration of greenhouse gases) to avoid "dangerous interference with the world's climate system."[59] Leading climate scientists such as Dr. James Hansen assert that a 1.5°C (about 350 ppm) target is necessary to avert the loss of the Greenland ice sheet, mass extinctions,

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54. Susan Solomon et al., *Irreversible Climate Change Due to Carbon Dioxide Emissions*, PROCEEDINGS OF THE NAT'L ACADEMY OF SCI. (Nov. 12, 2008), http://www.pnas.org/content/early/2009/01/28/0812721106.full.pdf+html.

55. The U.S. Geological Survey Climate and Land Use Change Research and Development Program defines abrupt climate change as follows:

> Abrupt climate change is defined as a large-scale change in the climate system that takes place over a few decades or less, persists (or is anticipated to persist) for at least a few decades, and causes substantial disruptions in human and natural systems. Study of past abrupt changes, preserved in paleoclimate records, provides important evidence on impacts of events that were so rapid and large that recurrence would pose significant risks for society. Examples of such abrupt events include: rapid changes in glaciers and ice sheets that affect sea level, widespread and sustained changes to the hydrologic cycle, shifts in northward flow of warm, salty water in the upper layers of the Atlantic Ocean related to Atlantic Meridional Overturning Circulation, and rapid release of methane trapped in permafrost and on continental margins to the atmosphere.

Abrupt Climate Change, USGS (Jan. 24 2013), http://www.usgs.gov/climate_landuse/clu_rd/pt_abrupt_cc.asp.

56. Lenton et al., *Tipping Elements in the Earth's Climate System*, 105(6) PROC. NAT'L ACAD. SCI. 1786–93 (2008).

57. Carl Zimmer, *An Ominous Warning on the Effects of Ocean Acidification*, YALE ENV'T 360 (Feb. 16, 2010), http://e360.yale.edu/feature/an_ominous_warning_on_the__effects_of_ocean_acidi fication/ 2241/.

58. Andy Ridgwell & Daniela N. Schmidt, *Past constraints on the Vulnerability of Marine Calcifiers to Massive Carbon Dioxide Release*, 3 NATURE GEOSCIENCE 196–200 (2010).

59. The Copenhagen Agreement (or Accord) is a document that delegates at the 15th session of the Conference of Parties ("COP 15") to the United Nations Framework Convention on Climate Change agreed to "take note of" at the final plenary on 18 December 2009. The Accord, which was drafted by the United States and the BASIC countries (China, India, South Africa, and Brazil), is not legally binding. Copenhagen Agreement, Framework Convention on Climate Change, Dec. 18, 2009, *available at* http://unfccc.int/resource/docs/2009/cop15/eng/l07.pdf.

and many other calamities. The debate is largely academic. The pledges in the Accord are too weak to achieve 2°C target.[60] Some experts say that to have even a fifty-fifty chance of achieving 2°C the world would have to limit GHG emissions to one trillion tons per year.[61] To achieve this target, global emissions would have to peak in the next few years and decline by three to four percent each year thereafter.[62] Instead, global emissions increased by six percent in 2011[63] due in large part to the rapid development of nations like China, India and Brazil.[64] Even the staid World Bank is warning that the world is barreling down a path toward 4°C at the end of the century, a scenario that could trigger a series of cataclysmic changes including extreme heat-waves, declining global food stocks, and a sea-level rise affecting hundreds of millions of people.[65]

In addition to climate concerns, a rising middle class in the developing world and a population of nine billion by 2050 is setting the stage for significant increases in energy demand. Approximately 1.3 billion people worldwide currently live without electricity.[66] The majority of these individuals are in Asia and Africa.[67] This stark reality, coupled with a rising middle class in countries like China and India, raises important questions about how to satisfy future energy demands while achieving climate stabilization. If developing nations promote energy models grounded primarily in fossil-based generation, without a scalable method for controlling GHG emissions, climate targets become increasingly unrealistic.

The United States should be leading the international effort on climate change legislation. A recent poll suggests that Americans consider climate change a top political priority.[68] Of those surveyed, 62 percent supported greenhouse gas reductions and power plant regulations and 54 percent responded that U.S. energy policy should prioritize renewables investment.[69] The United States should heed the International Energy Agency's ("IEAs") clarion call for an immediate shift away from fossil fuels. In its 2012 World Energy Outlook Factsheet, the IEA warned that the world has precisely five years to shift investment away from fossil fuel sources or

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60. Rogelj et al., *Copenhagen Accord Pledges Are Paltry*, 464 NATURE 1126, 1126–28 (2010).

61. M. R. Allen et al., *Warming Caused by Cumulative Carbon Emissions Towards the Trillionth Tonne*, 458(7242) NATURE 1163 (2009).

62. Rogelj et al., *supra* note 60, at 1128.

63. *Global Carbon-Dioxide Emissions Increase by 1.0 Gt in 2011 to Record High*, INT'L ENERGY AGENCY, http://www.iea.org/newsroomandevents/news/2012/may/name,27216,en.html (last visited Mar. 16, 2013).

64. *Id.*

65. THE WORLD BANK, TURN DOWN THE HEAT: WHY A 4°C WORLD MUST BE AVOIDED, ix (2012). World Bank President Jim Yong Kim summed up the message this way: "Lack of action on climate change threatens to make the world our children inherit a completely different world than we are living in today. Climate change is one of the single biggest challenges facing development, and we need to assume the moral responsibility to take action on behalf of future generations, especially the poorest." *Id.*

66. *Global Status of Modern Energy Access*, WORLD ENERGY OUTLOOK, http://www.worldenergyoutlook.org/resources/energydevelopment/globalstatusofmodernenergyaccess/#d.en.8609 (last visited Apr. 1, 2013).

67. *Id.*

68. PEW RESEARCH CTR. & USA TODAY, *Deficit Reduction: Focus Mostly on Spending but Keep Taxes in Mix, if No Deal is Struck, Four-in-Ten Say Let the Sequester Happen*, PEOPLE PRESS 13 (2013), http://www.people-press.org/files/legacy-pdf/02-21-13%20Political%20Release.pdf.

69. *Id.*

risk a carbon "lock-in" that will close the door on achieving 2°C forever.[70] More startling, IEA stated that two thirds of known fossil fuel reserves must remain in the ground if we are to achieve 2°C.[71] Delay is costly. According to the IEA, "delaying action is a false economy: for every $1 of investment in cleaner technology that is avoided in the power sector before 2020, an additional $4.30 would need to be spent after 2020 to compensate for the increased emissions."[72]

With this background we turn to an examination of where natural gas fits into our energy future.

A. Available Evidence Belies Claims that Switching from Coal to Natural Gas Will Produce Significant Climate Benefits

Central to the debate about the climate benefits of natural gas as a bridge fuel is the rate of methane leakage from the life cycle of unconventional gas. Empirical data is sorely lacking, and there is sharp disagreement among experts about how to interpret the little information available.

What we do know is that, on average, natural gas combustion emits about half as much CO_2 as coal per unit of energy.[73] This suggests that gas is preferable to coal—at least from a climate standpoint.[74] However, when life cycle emissions of methane are taken into account, the picture is less clear. Gas is eighty percent methane,[75] and methane is the second largest contributor to global warming next to carbon dioxide.[76] The global warming potential ("GWP") of methane is about twenty-five times greater than CO_2 over a one hundred-year time frame and seventy-one times greater over a twenty-year period.[77] Reducing short-term climate accelerators such as methane and black carbon[78] is the highest priority for slowing the

70. INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK FACTSHEET 2012, 3 (2012), *available at* http://www.worldenergyoutlook.org/media/weowebsite/2012/factsheets.pdf.

71. *Id.*

72. Maria van der Hoeven, *Energy Security: Looking Towards Uncertainty*, (March 8, 2012), http://www.iea.org/newsroomandevents/news/2012/march/name,19915,en.html.

73. *How Much Carbon Dioxide (C02) Is Produced When Different Fuels Are Burned?*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/tools/faqs/faq.cfm?id=73&t=11 (last visited Mar. 16, 2013).

74. Only one-third of gas is used for electricity. *Basic Information*, U.S. ENERGY PROT. AGENCY, http://www.eia.gov/dnav/ng/ng_cons_sum_dcu_nus_a.htm (last visited Jan. 16, 2013). Cheap gas will mean more consumption by buildings, industry, and perhaps for transportation. In many of these sectors, cheap gas will not edge out coal or any other fuel, we will just burn more of it.

75. *Overview of Natural Gas*, NATURALGAS, http://www.naturalgas.org/overview/background.asp (last visited Mar. 16, 2013).

76. *What Are Greenhouse Gases and How Do They Affect the Climate?*, U.S. ENERGY INFO. ADMIN., http://www.eia.gov/tools/faqs/faw.cfm?id=81&t=11 (last visited Mar. 16, 2013).

77. *Global Warming Potentials*, UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, http://unfccc.int/ghg_data/items/3825.php (last visited Mar. 16, 2013).

78. Black carbon, more commonly known as soot, is "the most strongly light-absorbing component of particulate matter (PM), and is formed by the incomplete combustion of fossil fuels, biofuels, and biomass." *Basic Information*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/blackcarbon/ basic.html (last visited Jan. 16, 2013. The principal sources are diesel emissions, burning of agricultural waste and heating and cooking. *Id.* Black carbon can absorb a million times more energy than carbon dioxide ("CO_2"). *Id.* Black carbon has been linked to a range of climate impacts, including increased temperatures and accelerated ice and snow melt. *Id.* Sensitive regions such as the Arctic and the Himalayas are particularly vulnerable to the warming and melting effects of black carbon. *Id.*

pace of climate change, according to climate scientists.[79] Reducing these emissions, even if carbon dioxide is not controlled, would significantly slow the rate of global warming and postpone reaching the 1.5°C and 2.0°C marks by twelve to fifteen years.[80]

Natural gas systems are the single largest source of anthropogenic methane emissions in the United States.[81] Surprisingly, however, there has been no systematic effort to measure leakage rates throughout the gas production cycle. This would include measurements from wells during the extraction process, the processing equipment while compressing or drying gas, and the poorly sealed equipment while transporting and storing it.[82] Estimates of methane leakage rates based on models vary widely whereas rates as high as nine percent of total production have been measured at specific locations. The EPA uses "emission factors" based on industry reports to estimate total methane leakage.[83] The earliest of these emission factors were adopted in 1996. In 2010 EPA updated these estimates for "upstream and mid-stream" sources [84] and found them to be as much as 8,000 times greater than the 1996 estimates.[85] This increase in estimated emissions is driven largely by the rapid expansion of fracking. According to the National Petroleum Council, an estimated sixty to eighty percent of all gas wells drilled in the next decade will require the technique known as hydraulic fracturing or fracking.[86] The fracking process injects a mixture of water, sand, and chemical additives ("frack fluid") at high pressure into rock formations (shale, tight sands, or coal-bed methane), creating fractures and releasing the trapped gas. The frack fluid is then drawn back out, during a period known as "flowback," in order to prepare the well for production ("well completion"). During this phase, a significant amount of methane breaks the surface and is typically vented into the atmosphere. Because fracking has accelerated natural gas development, accurate information about methane

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79. *Ministers from 25 Nations Commit to Scaling Up Voluntary Actions to Reduce Short Term Climate Pollutants*, UNITED NATIONS ENV'T PROGRAM, http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=2700&ArticleID=9348&l=en (last visited Mar. 16, 2013).

80. Drew Shindell et al., *Simultaneously Mitigating Near-term Climate Change and Improving Human Health and Food Security*, 335 SCI. 183–89 (2012).

81. *See Sources and Emissions*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/outreach/sources.html (last visited Jan. 16, 2013). Coal mining is the fourth leading source of methane. *Id.*

82. MARK FULTON ET AL., COMPARING LIFE-CYCLE GREENHOUSE GAS EMISSIONS FROM NATURAL GAS AND COAL 20 (2011), *available at* http://www.worldwatch.org/system/files/pdf/Natural_Gas_LCA_Update_082511. pdf.

83. *See Basic Emissions Factors Information*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/ttnchie1/efpac/abefpac.html (last visited Jan. 16, 2013).

84. There are three stages to consider: upstream (well site), midstream (processing facilities), and downstream (storage, transmission and distribution). Reliable data on all three stages is lacking. *See generally* ROBERT HOWARTH ET AL., METHANE EMISSIONS FROM NATURAL GAS SYSTEMS (2012), *available at* http://www.eeb.cornell.edu/howarth/Howarth%20et%20al.%20--%20National%20Climate%20Assessment.pdf.

85. U.S. ENVTL. PROT. AGENCY, GREENHOUSE GAS EMISSIONS REPORTING FROM THE PETROLEUM AND GAS INDUSTRY (2010), *available at* http://www.epa.gov/ghgreporting/documents/pdf/2010/Subpart-W_TSD.pdf.

86. AM. EXPLORATION AND PRODUCTION COUNCIL, HYDRAULIC FRACTURING: ACTION NEEDED TO REMOVE REGULATORY UNCERTAINTY (2003).

leakage rates is critical for assessing the cumulative GHG impact of continued large-scale development of natural gas.

United States Inspector General for the EPA, Arthur Elkins, recently expressed concern in an EPA report that methane emission data was insufficient for making informed and reliable policy decisions.[87] In the report, Elkin states that "with limited data, human health risks are uncertain, states may design incorrect or ineffective emission control strategies and EPA's decisions about regulating industry may be misinformed."[88] In its latest greenhouse gas inventory report, EPA states that emissions from natural gas systems have decreased by 10.2 percent since 1990.[89] EPA also states that "[e]missions from field production accounted for approximately 37 percent of CH4 emissions from natural gas systems in 2011." However, these figures are taken from industry reports that have not been independently verified.[90] EPA also notes that the trend in field production "was not stable over the time series-emissions from this source increased by 43 percent from 1990 through 2006, and then declined by 38 percent from 2006 to 2011."[91] A recent independent study sampling the air overlying a natural gas field in Colorado found that the leakage rate might well be twice as high as the industry-reported figures.[92]

Tom Wigley, a climate scientist at the National Center for Atmospheric Research ("NCAR"), recently examined the effect of replacing a portion of coal generation with natural gas (up to fifty percent) on the global mean temperature.[93] Wigley finds that, due to a combination of increased methane leakage and reduced SO_2 emissions,[94] substituting gas for coal actually leads to a slight (0.1°C) increase in global warming.[95] Wigley concludes that "unless leakage rates for new methane can be kept below two percent, substituting gas for coal is not an effective means for reducing the magnitude of future climate change."[96]

A pair of studies led by Cornell Professor Robert Howarth has sparked a heated debate by suggesting that the greenhouse gas footprint of unconventional natural gas development is worse than coal. After reviewing the published leakage estimates, including those provided by EPA, the gas industry, as well as independent investigations, Howarth calculated an average methane leakage rate of 2.6 percent from natural gas wells over their production lifetime, with 1.7 percent from upstream and midstream emissions and 0.9 percent from downstream emissions.[97] Howarth emphasized the need for examining both the twenty- and one hundred-

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87. U.S. ENVTL. PROT. AGENCY, EPA NEEDS TO IMPROVE AIR EMISSIONS DATA FOR THE OIL AND NATURAL GAS PRODUCTION SECTORS (2013), *available at* http://www.epa.gov/oig/reports2013/20130220-13-P-0161.pdf.

88. *Id.*

89. U.S. ENVTL. PROT. AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2011, ES-13 (Apr. 2013), *available at* http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-ES.pdf.

90. *Id.*

91. *Id.*

92. Petron et al., *Hydrocarbon Emissions Characterization in the Colorado Front Range: A Pilot Study*, 117 J. GEOPHYSICAL RES. 17, 17–18 (2012).

93. Tom M. L. Wigley, *Coal to Gas: the Influence of Methane Leakage*, 108 CLIMATIC CHANGE, 601–08 (2011), *available at* http://nldr.library.ucar.edu/repository/assets/osgc/OSGC-000-000-010-533.pdf.

94. Sulfate aerosols act as a cooling agent by reflecting sunlight.

95. Wigley, *supra* note 93, at 602.

96. *Id.* at 607.

97. HOWARTH ET AL., *supra* note 84, at 2.

year time frames in evaluating the impact of methane leakage on the climate.[98] After noting the paucity of actual emissions data and the need to "accurately characterize the site to site variability in emissions,[99]" Howarth concluded, "it is likely that leakage at individual natural gas well sites is high enough, when combined with leakage from downstream operations, to make the total leakage exceed the 3.2% threshold beyond which gas becomes worse for the climate than coal for at least some period of time."[100]

In his follow-up study, prepared as a background paper for the National Climate Assessment, Howarth expanded upon his earlier analysis and reaffirmed his conclusion that methane leakage from all natural gas systems will contribute seventeen percent of the entire GHG inventory of the United States over the next twenty years.[101] Howarth added that "these estimates may be low, and that the gradual replacement of conventional natural gas by shale gas is predicted to increase these methane fluxes by 40% to 60% or more."[102] The Howarth studies have been sharply criticized by the gas industry[103] and by some of his colleagues at Cornell[104] who claim that the estimates of methane emissions are exaggerated and that use of the one hundred-year time frame is more appropriate than twenty years for analysis of climate benefits.

Howarth's leading critic is Lawrence Cathles, Professor of Earth and Atmospheric Studies at Cornell. In his initial study published in January 2012, Cathles and his colleagues concluded that Howarth's study is flawed in several respects: (1) that it "significantly overestimate[s] the fugitive emissions associated with unconventional gas extraction;" (2) that it "undervalue[s] the contribution of 'green technologies' to reducing those emissions to a level approaching that of conventional gas;" (3) that it incorrectly bases the "comparison between gas and coal on heat rather than electricity generation;" and (4) that it "assume[s] a time interval over which to compute the relative climate impact of gas compared to coal that does not capture the contrast between the long residence time of CO_2 and the short residence time of methane in the atmosphere."[105]

98. *Id.* at 7.

99. Ramòn A. Alvarez, *Greater Focus Needed on Methane Leakage from Natural Gas Infrastructure*, 109 PROC. OF THE NAT'L ACAD. OF SCI. 6435, 6437 (2012).

100. Joe Romm, *Natural Gas Is A Bridge To Nowhere Absent A Carbon Price AND Strong Standards To Reduce Methane Leakage*, THINKPROGRESS (Apr. 9, 2012, 4:50 PM), http://thinkprogress.org/climate/2012/04/09/460384/natural-gas-is-a-bridge-to-nowhere-absent-a-carbon-price-and-strong-standards-to-reduce-methane-leakage/.

101. *Id.* at 8.

102. *See* HOWARTH ET AL., *supra* note 84.

103. *Howarth: A Credibility Gap*, AM. NATURAL GAS ALLIANCE, http://anga.us/critical-issues/howarth-a-credibility-gap (last visited Apr. 13, 2013).

104. Lawrence M. Cathles III et al., *A Commentary on "The Greenhouse-Gas Footprint of Natural Gas in Shale Formations" by R.W. Howarth, R. Santoro, and Anthony Ingraffea*, 113 CLIMATIC CHANGE 525 (2012), *available at* http://link.springer.com/content/pdf/10.1007%2Fs10584-011-0333-0. Howarth and his colleagues quickly issued a rebuttal. *See generally* Robert W. Howarth et al., *Venting and Leaking of Methane from Shale Gas Development: Response to Cathles et al.*, CLIMATIC CHANGE (Jan. 10, 2012), available at http://www.eeb.cornell.edu/ howarth/Howarthetal2012_Final.pdf.

105. Cathles III et al., *supra* note 104.

Amidst these criticisms, an independent study has recently emerged lending credence to the higher emission rates used by Howarth.[106] The study, carried out by scientists holding joint appointments with the National Oceanic and Atmospheric Administration ("NOAA") and the University of Colorado in Boulder, is a follow up to the study of the Colorado gas field study noted above. The study found leakage rates of four percent—nearly twice the rate of EPA projections.[107] Similar findings were presented at a meeting of the American Geophysical Union ("AGU") in March 2013. A research team from NOAA and the University of Colorado reported new Colorado data, supporting earlier findings, as well as preliminary data from the Uinta Basin of Utah, which suggested even higher methane leakage rates—a staggering nine percent of the total production.[108] That figure is nearly double the cumulative loss rates estimated from industry data, which are already higher in Utah than in Colorado.[109] To quote NOAA's Colm Sweeny: "We were expecting to see high methane levels, but I don't think anybody really comprehended the true magnitude of what we would see."[110]

The above studies emphasize the uncertainty of the data upon which current methane emission estimates are built. More information is needed on the nature and impact of methane losses from the production itself, as well as from the processing, transmission, and distribution of natural gas. In recent reports, the Secretary of Energy Advisory Board has called for better information on the environmental impacts of fracking.[111] Separately, the Environmental Defense Fund and a coalition of partners from academia, regulators, and the industry have launched a series of field studies to gather more data.[112]

The importance of getting the leakage numbers right becomes more critical when you consider that the global background carbon dioxide concentration is closing in on 400 ppm and that it is going up by roughly two ppm per year.[113] Once it gets to 450 ppm, many experts suspect we will have lost our opportunity to avoid certain destructive tipping points such as the melting of permafrost or the loss of the Greenland ice sheet.[114] The window of opportunity to alter this destructive course is rapidly closing. Leakage of four percent, let alone nine percent, would call into question the value of natural gas as any sort of bridge fuel.[115]

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106. Jeff Tollefson, *Methane Leaks Erode Green Credentials of Natural Gas*, NATURE (Jan. 2, 2013), http://www.nature.com/news/methane-leaks-erode-green-credentials-of-natural-gas-1.12123?nc=1357473351839 (last visited Jan. 16, 2013).

107. *Id.*

108. *Id.*

109. *Id.*

110. *Id.*

111. NATURAL GAS SUBCOMMITTEE, ENERGY ADVISORY BOARD, SHALE GAS PRODUCTION SUBCOMMITTEE NINETY DAY REPORT (Aug. 18, 2011), *available at* http://www.shalegas.energy.gov/resources/081811_90_day_report_final.pdf.

112. *Study Will Measure Methane Leakage During Natural Gas Operations*, ENVTL. DEFENSE FUND (Oct. 11, 2012), http://www.edf.org/news/2012/10/11/study-will-measure-methane-leakage-during-natural-gas-operations (last visited Mar. 16, 2013).

113. *How Much Carbon Dioxide (and Other Kinds of Greenhouse Gas) Is Already in the Atmosphere?*, UNIV. CORP. FOR ACAD. RESEARCH, http://www2.ucar.edu/climate/faq/how-much-carbon-dioxide-and-other-kinds-greenhouse-gas-already-atmosphere (last visited Mar. 16, 2013). As of mid-2012, the seasonally adjusted concentration of CO_2 in Earth's atmosphere was about 394 ppm, with a steady recent growth rate of about 2 ppm per year. *Id.*

114. Romm, *supra* note 44.

115. *See* Tollefson, *supra* note 106.

B. Better Controls on Methane Leakage Should be a Top Priority

Since 1993, EPA has sponsored the Natural Gas STAR Program, a voluntary commitment from oil and natural gas companies around the world to adopt cost-effective technologies and practices in an effort to reduce methane emissions and enhance operational efficiency.[116] The program targets the major industry sectors that deliver natural gas to end users.[117] The participants represent fifty-nine percent of the natural gas industry in the United States.[118] According to EPA figures, the program has eliminated more than 994 billion cubic feet ("bcf") of methane emissions by implementing approximately 150 cost-effective technologies and practices.[119]

But voluntary measures only go so far. The Clean Air Act mandates reduction of emissions of volatile organic compounds, air toxics, and methane.[120] Prodded by litigation, EPA has recently updated the New Source Performance Standards ("NSPS") for the oil and gas industry to address air quality problems.[121] The final rules, which took effect in July 2012, include the first federal air standards for hydraulically for fractured gas wells, along with requirements for other pollution sources in the oil and gas industry for which there are currently no federal standards.[122] However, rather than require numerical performance standards for all methane emissions, the rules require "green completions."[123] During a green completion, equipment with exotic names like "plunger lift systems" and "TEG dehydrator emission controls," capture vented, leaked or otherwise wasted natural gas from wells during the fracking process.[124] There are at least ten techniques for capturing these emissions; and, according to EPA, the value of the captured gas more than offsets the costs.[125] EPA estimates that green completions can reduce emissions during the well completion process by ninety-five percent and projects revenues from the captured gas to offset controls costs and yield $11 to 19 million in sav-

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116. *Natural Gas STAR Program Accomplishments*, U.S. ENVTL. PROT. AGENCY (Sept. 27, 2012), http://www.epa.gov/gasstar/accomplishments/index.html (last visited Jan. 16, 2013).

117. *Id.*

118. *Id.*

119. *Id.*

120. 42 U.S.C. § 7411 (2006). Section 111 of the Clean Air Act requires the EPA to establish standards of performance for emissions of air pollutants which reflects the degree of emission limitation achievable through the application of the best system of emission reduction which (taking into account the cost of achieving such reduction and any non-air quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated. These standards are often referred to as new source performance standards, or NSPS standards. *See Compliance Monitoring*, U.S. ENVTL. PROT. AGENCY (Jun. 13, 2012), http://www.epa.gov/oecaerth/monitoring/programs/caa/newsource.html (last visited Mar. 16, 2013).

121. *Oil and Natural Gas Sector — New Source Performance Standards and National Emission Standards for Hazardous Air Pollutants*, U.S. ENVTL. PROT. AGENCY, http://yosemite.epa.gov/opei/rulegate.nsf/byRIN/2060-AP76 (last visited Mar. 16, 2013).

122. *Id.*

123. *Id.*

124. NAT'L RES. DEFENSE COUNCIL, LEAKING PROFITS: THE U.S. OIL AND GAS INDUSTRY CAN REDUCE POLLUTION, CONSERVE RESOURCES, AND MAKE MONEY BY PREVENTING METHANE WASTE (Mar. 2012), *available at* http://www.nrdc.org/energy/files/Leaking-Profits-FS.pdf.

125. *Overview of Final Amendments to Air Regulations for the Oil and Natural Gas Industry Fact Sheet*, U.S. ENVTL. PROT. AGENCY, http://epa.gov/airquality/oilandgas/pdfs/ 20120417fs.pdf (last visited Jan. 16, 2013).

ings.[126] EPA is giving the industry a one-year grace period (until January 1, 2015) to ensure green completion equipment is broadly available. During this transition period, fracked and refracked wells must reduce their emissions through flaring. These new rules will not, however, reduce methane emissions from gas processing or pipelines.[127]

Most notably, EPA did not set a specific performance standard for methane. Rather, methane reduction through green completions is an incidental benefit of the NSPS rules. Frustrated by EPA's lack of action, seven states, led by New York, have served a formal notice of intent to sue the agency under the Clean Air Act.[128] Specifically, the coalition argues that section 111 of the CAA imposes on the EPA "a mandatory duty (1) to make a determination whether standards covering methane emissions are 'appropriate,' and, (2) if it is appropriate, to promulgate standards."[129] It is undisputed that EPA did not make a formal determination as to whether a specific NSPS for methane was appropriate, so there appears to be some merit to the states' case.

Meanwhile, industry and environmental organizations have petitioned the D.C. Circuit for review of the NSPS rules.[130] Industry argues that larger gas operations require a three-year phase-in, rather than the one-year compliance period EPA allows for, reasoning that sufficient control equipment will not be available on time.[131] The Petition for review does not specify the grounds for challenging the rule, but environmentalists have been long pushed for stronger controls on methane escaping from oil and gas wells.[132] Environmentalists maintain that EPA's rule fails to limit methane from a number of sources, including existing gas wells and oil wells, as well as transmission, distribution and storage facilities.[133] In the preamble to the final rule, EPA explained that it lacked sufficient information to impose such controls.[134]

In short, the NSPS issue is far from settled.

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126. *Overview of Final Amendments to Air Regulations for the Oil And Gas Industry*, U.S. ENVTL. PROT. AGENCY, http://www.epa.gov/airquality/oilandgas/pdfs/20120417fs.pdf (last visited Jan. 16, 2013).

127. *See id.*

128. *See* Letter from Eric T. Schneiderman, New York Attorney General et al. to Lisa P. Jackson, Administrator, Environmental Protection Agency, (Dec. 11, 2012), *available at* http://www.ag.ny.gov/pdfs/ltr_NSPS_Methane_Notice.pdf.

129. *Id.*

130. Stuart Parker, *EPA Draws Multiple Industry, Environmentalist Suits Over Drilling Air Rules* INSIDEEPA, (Oct. 17, 2012), http://insideepa.com/Inside-EPA-General/Inside-EPA-Public-Content/epa-draws-multiple-industry-environmentalist-suits-over-drilling-air-rules/menu-id-565.html?S=LI (last visited Jan. 16, 2013). "Industry groups filing suit against EPA in the D.C. Circuit are the American Petroleum Institute (API), the Texas Oil and Gas Association (TXOGA), the Gas Processors Association, the Independent Petroleum Association of America and allied state groups, the Western Energy Alliance and the Domestic Energy Producers Alliance. Environmental groups filing suit include the Natural Resources Defense Council (NRDC), Sierra Club, Environmental Defense Fund, Clean Air Council and others." *Id.*

131. *Id.*

132. *Id.*

133. *Id.*

134. *See id.*

C. Cheap Natural Gas Might Delay but Cannot Avoid Dangerous Climate Outcomes

In the ironically titled "Golden Rules for a Golden Age of Gas," the IEA estimates that if all we do is substitute gas for coal, the world would still be on track to increase atmospheric carbon emissions to about 650 ppm—"a trajectory consistent with a probable temperature rise of more than 3.5°C in the long term and well above the 2°C target."[135] This same report highlights the environmental benefits of substituting natural gas for other fossil fuels, yet maintains that gas alone is not sufficient to address the challenges climate change presents."[136]

Exceeding the 3.5°C threshold would likely exceed the adaptive capacity of most nations on earth, according to Kevin Anderson, former director of the Tyndall Center.[137] Again, it is the cumulative loadings of carbon and methane in the atmosphere that matter.[138] Given the urgency of the situation, it would be misleading to assume that a transition from coal to natural gas would lead to a stable climate. Temperature is a function of how much CO_2 accumulates in the atmosphere. It is more like a budget than a target. If we use up fifty percent of the carbon budget, we only have fifty percent left to allocate or suffer the consequences of going into deficit. For example, to achieve a 4°C target would require that carbon emissions peak by 2020 and decline by three percent thereafter.[139] But that would leave us with a climate that "is incompatible with an organized global community, is likely to be beyond 'adaptation', is devastating to the majority of ecosystems, and has a high probability of not being stable."[140] Indeed, natural gas holds appeal for a stable climate regime when considering its relatively low carbon emissions. However, a 2012 IEA report clarifies the danger in this assumption: "Gas-fired plants may emit only half as much carbon dioxide per kilowatt-hour generated than coal-fired plants, but by 2025 the amount emitted will be higher than the average for the entire electric system."[141] The report goes on to recommend that as CO_2 reductions deepen after 2030, gas-powered generation should increasingly serve to complement variable renewable energies and provide peak-load power to balance out intermittent generation and demand fluctuations.[142]

Timetables are integral to any discussion concerning natural gas as a bridge fuel. The time it takes to transition from a carbon-intensive source like coal to a lower carbon source like gas is problematic. A study by tech guru Nathan

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135. INT'L ENERGY AGENCY, GOLDEN RULES FOR A GOLDEN AGE OF GAS, WORLD ENERGY OUTLOOK SPECIAL REPORT ON UNCONVENTIONAL GAS 91–92 (2012), *available at* http://www.worldenergyoutlook.org/media/weowebsite/2012/goldenrules/WEO2012_GoldenRulesReport.pdf [hereinafter INT'L ENERGY AGENCY, GOLDEN RULES].

136. *Id.* at 91.

137. Kevin Anderson &Alice Bows, *Beyond "Dangerous" Climate Change: Emission Scenarios For a New World*, 369 PHIL. TRANSACTIONS ROYAL SOC'Y A 20, 40 (2011).

138. Kevin Anderson, Public Lecture: Going Beyond Dangerous Climate Change: Exploring the Void Between Rhetoric and Reality in Reducing Carbon Emissions (Oct. 21 2011), *available at* http://www2.lse.ac.uk/newsAndMedia/videoAndAudio/channels/publicLecturesAndEvents/player.aspx?id=1208.

139. *Id.*

140. *Id.*

141. *See generally* INT'L ENERGY AGENCY, ENERGY TECHNOLOGY PERSPECTIVES 2012: PATHWAYS TO A CLEAN ENERGY SYSTEM (2012).

142. *Id.* at 111.

Myrhvold and climate scientist Ken Caldeira underscores this issue. The study looked at transition scenarios for various energy sources and found that a transition to natural gas would require a century or longer to attain even a twenty-five percent reduction in high GHG warming.[143] The study also noted that while conservation, renewables, nuclear power, carbon capture, and storage appear capable of achieving "substantial climate benefits in the second half of this century," the same was not true for natural gas.[144] Based on extensive modeling of natural gas as a bridge fuel for climate stabilization, Michael Levi of the Council on Foreign Relations has concluded that "absent carbon capture and sequestration, a natural gas bridge is of limited direct emissions-reducing value, since that bridge must be short."[145] Levi goes on to say that natural gas "could play a more important role in the context of more modest but still stringent objectives (550 ppm CO_2) which are compatible with longer natural gas bridges."[146]

The problem is that 550 ppm is far from a safe threshold for climate stability according to many of the most knowledgeable climate scientists. In the Copenhagen Accord, for example, the signatory nations, including the United States, agreed that 450 ppm represented the threshold for "dangerous anthropogenic interference with the climate."[147] Further, as noted, James Hansen and other distinguished scientists argue forcefully that 350 ppm is the only safe limit. As Levi observes:

> [I]t may be useful to think of a natural gas bridge as a potential hedging tool against the possibility that it will be more difficult to move away from coal than policymakers desire or can achieve, rather than merely (or primarily) as a way to achieve particular desired temperature outcomes.

In other words, natural gas is a bridge too far for a stable climate regime.[148] Depending on how gas is used, it could complement the deployment of wind and solar or, as described below, it could impede renewables and defeat carbon reduction goals.

D. The Gas Boom Threatens to Undercut Deployment of Renewables and Lock in Dangerous Levels of Greenhouse Gas Emissions

Adam James, with the Center for American Progress, recently captured the essence of the challenge facing the United States at this time:

143. Nathan P. Myrvold & Ken Caldeira, *Greenhouse Gases, Climate Change and the Transition from Coal to Low-Carbon Electricity*, 7 ENVTL. RESEARCH LETTERS 1.5 (2012).

144. *Id.* at 1. The David Suzuki Foundation has released a report reaching a similar conclusion regarding gas development in Canada. *See generally* MATTHEW BRAMLEY, IS NATURAL GAS A CLIMATE CHANGE SOLUTION FOR CANADA? (2011), *available at* http://www.davidsuzuki.org/publications/downloads/2011/DSF-Pembina-NatGas-web.pdf.

145. Michael Levi, *Climate Consequences of Natural Gas as a Bridge Fuel*, CLIMATIC CHANGE (Jan. 3, 2013), http://www.cfr.org/energyenvironment/climate-consequences-natural-gas-bridge-fuel/p29772. Levi argues that methane leakage rates, even the five percent rate postulated by Howarth, do not have much bearing on climate stabilization. This is questionable in light of the concern of scientists with the short-term climate forcing properties of methane. *Id.*

146. *Id.*

147. U.N. Framework Convention on Climate Change, GE.05-622204 (1992), *available at* http://unfccc.int/resource/docs/convkp/conveng.pdf.

148. Levi, *supra* note 145.

> The bottom line is this: in order to meet climate targets, the United States needs to build only planned additions and, starting in 2023, retire all natural gas plants over forty-five years old. This will allow the United States to develop renewable alternatives and not waste excess natural gas capacity through uneconomic retirements later in an effort to meet climate goals.[149]

Accommodating a large-scale shift toward natural gas assumes an investment of billions of dollars' worth of wells, pipelines, storage, and additional midstream infrastructure investments.[150] Looking at three different market scenarios for the United States and Canada from 2009 through 2030, midstream infrastructure expenditures ranged from $133 to 210 billion.[151] Projected construction included 28,900 to 61,900 miles of added pipeline,[152] and the EIA forecasts an additional 630,000 new wells.[153] According to the Aspen Environmental Group, "[t]he magnitude of the investment that would be needed seems inconsistent with the oft-touted idea of natural gas as a temporary 'bridge' fuel."[154] This is not to say that the U.S. should not invest in natural gas infrastructure; on the contrary, a moderate amount of investment is necessary for natural gas to supplement intermittent renewable resources.

Investing in an energy model predicated on the continued vitality of natural gas presents several high-stakes gambles. First, it makes a number of assumptions about future energy prices and the direction of national energy policy that may or may not materialize. Due to its finite nature, historic price volatility,[155] and accident-prone infrastructure,[156] investing in a natural gas-based future is inherently risky and unsustainable. Analysts are also forecasting that the United States will become a natural gas net exporter by 2020,[157] which could reduce domestic supply and add to the fuel's price instability.[158] Investments in natural gas infrastructure assume that gas prices will remain attractive, and that the cost of construction, regulatory compliance, and externalities like water supply constraints, waste disposal, seismic events, air pollution, and GHG emissions will not lead to a significant rise in costs. But because energy systems are dynamic and prone to flux,

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149. Adam James, *U.S. Natural Gas Capacity Must Peak Soon to Achieve Sustainable Pathway*, THINK PROGRESS CLIMATE PROGRESS (Dec. 10, 2012), http://thinkprogress.org/climate/2012/12/10/1296991/how-the-us-can-get-80-percent-co2-reductions-by-2050-in-the-middle-of-a-natural-gas-boom/.

150. ICF INT'L, NATURAL GAS PIPELINE AND STORAGE INFRASTRUCTURE PROJECTIONS THROUGH 2030 3–4 (2009), *available at* http://www.ingaa.org/File.aspx?id=10509.

151. *Id.*

152. *Id.* at 3.

153. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2012 59 (2012), *available at* www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf.

154. ASPEN ENVTL. GROUP, IMPLICATIONS OF GREATER RELIANCE ON NATURAL GAS FOR ELECTRICITY GENERATION 2 (2010), *available at* https://appanet.cms-plus.com/files/PDFs/ImplicationsOfGreaterRelianceOnNGforElectricityGeneration.pdf.

155. *U.S. Natural Gas Wellhead Price*, U.S. ENERGY INFO. ADMIN. (Jan. 7, 2013), http://www.eia.gov/dnav/ng/hist/n9190us3m.htm.

156. Pipelines "account[] for 33 percent of all major energy accidents worldwide." Donald McCubbin & Benjamin K. Sovacool, *The Hidden Factors That Make Wind Energy Cheaper Than Natural Gas in the United States*, 24 ELECTRICITY J. 85, 90 (2011), *available at* http://www.sciencedirect.com/science/article/pii/S1040619011002351.

157. INT'L ENERGY AGENCY, *supra* note 70, at 5.

158. MICHAEL LEVI, A STRATEGY FOR U.S. NATURAL GAS EXPORTS 5–8 (June 2012), *available at* http://www.brookings.edu/~/media/research/files/papers/2012/6/13%20exports%20levi/06_exports_levi.pdf %20levi/06_exports_levi.

countless variables are poised to derail present forecasts, leaving the fate of natural gas uncertain.

The volatility of New England's electricity market in the winter of 2012-13 highlights natural gas' price volatility and the market uncertainties that accompany an energy portfolio comprised primarily of gas.[159] Electricity prices skyrocketed to several times their normal rate as temperatures plummeted and demand outstripped supply.[160] Because natural gas comprises fifty-two percent of New England's electricity supply—a figure that is expected to rise in the future—utility companies anticipate that they will have to pay more for electricity that they purchase through long-term contracts with independent power producers. This is because, as the cost of natural gas rises (or becomes more volatile), these power producers will need "to absorb the risk of short-term spikes in prices."[161] Executive Director of Carnegie Mellon's Electricity Industry Center acknowledged that a region that "relies on a single fuel source like natural gas for the bulk of its power does leave itself open for more disruptions than a region with a more diverse fuel mix."[162]

In addition to purchasing a financially volatile fuel source, investors in natural gas also buy into a time horizon. History shows that it can take upwards of fifty years to successfully replace existing energy infrastructure.[163] In the case of natural gas, this time frame is supported by the average useful lifespan of its supporting infrastructure. Gas pipelines, for example, generally need to be replaced after thirty to fifty years.[164] Investments in these projects typically rely on long-term contractual commitments from suppliers, often locking in energy supplies for years.[165] Further, the maturity life for investment bonds can project decades out.[166] The EIA is projecting shale gas production to grow, rising from twenty-three percent of American gas production in 2010 to forty-nine percent in 2035.[167] As a result of this significant growth, future energy models built on a high degree of natural gas development assume great risk and commit natural gas to playing a major role in United States energy in the near future.

From a climate change perspective, the concern with natural gas is primarily scale. Climate models suggest that to limit global warming to 2°C, renewables must make up at least forty-three percent of the global energy portfolio by 2030 and seventy-seven percent by 2050.[168] This case reflects a high renewables penetration scenario.[169] Responding to these figures, the International Energy Agency ("IEA") said that "to achieve this would require a complete and rapid transformation of the

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159. Matthew L. Wald, *In New England, a Natural Gas Trap*, N.Y. TIMES (Feb. 15, 2013).

160. *Id.*

161. *Id.*

162. *Id.*

163. *See generally* VACLAV SMIL, ENERGY TRANSITIONS: HISTORY, REQUIREMENTS, PROSPECTS (2010).

164. *Id.*

165. *See* N. AM. ELECTRIC RELIABILITY CORP., 2011 SPECIAL RELIABILITY ASSESSMENT: A PRIMER OF THE NATURAL GAS AND ELECTRIC POWER INTERDEPENDENCY IN THE UNITED STATES 1, 8 (2011), *available at* http://www.nerc.com/files/Gas_Electric_Interdependencies_Phase_I.pdf.

166. *Fitch Rates Northern Natural Gas Company's Bonds 'A'; Outlook Stable*, REUTERS (Aug. 23, 2012, 2:32 PM), http://www.reuters.com/article/2012/08/23/idUSWNA402520120823.

167. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2012, *supra* note 153, at 3.

168. DAN ARVIZU ET AL., SUMMARY FOR POLICYMAKERS 19 (2011), *available at* http://srren.ipcc-wg3.de/report/IPCC_SRREN_SPM.pdf.

169. *Id.*; INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, SPECIAL REPORT ON RENEWABLE ENERGY SOURCES AND CLIMATE CHANGE MITIGATION (2011), *available at* http://srren.ipcc-wg3.de/.

energy sector."[170] If immediate action is not taken to reduce carbon emissions by 2017, the IEA warns that all permissible emissions would be "locked-in" by existing energy infrastructure, pushing temperatures beyond 2°C.[171] In its 2012 World Energy Outlook Factsheet, the IEA stated: "No more than one-third of proven reserves of fossil fuels can be consumed prior to 2050 if the world is to achieve the 2°C goal unless carbon capture and storage is widely deployed."[172] From this, it is fair to assume that any delay to an immediate and grand-scale transition to renewables serves as an obstruction to staving off irreversible climate damage.

The potential longevity for natural gas, combined with its expected large-scale infrastructure investment, upends the idea of natural gas serving as a transitional "bridge fuel" and raises the risk that it will lead to a dead end for climate policy. Creating a new energy paradigm takes time and infrastructure. Appropriate financial incentives, technological advancements, and political backing could reasonably shorten this time frame; however, the scale of several current natural gas projections signifies a long-term commitment to a fossil-driven energy model and a timetable that conflicts with climate science.

In sum, gas will impede renewables unless steps are taken to prevent it. As the authors of a trenchant essay in Yale Environment 360 put it, "The U.S. now faces a choice: We can rush into a monolithic energy future dominated by natural gas, or we can leverage the gift of cheap and abundant natural gas to create an energy system that is profitable, affordable, and more sustainable over the long run."[173]

To further this point, market and pricing trends and projections provide an important guidepost. Expanded gas reserves have driven down natural gas prices substantially, leading to a near seventy percent decline in price since 2008.[174] The IEA projects that natural gas will account for twenty-eight percent of the United States's primary energy demand by 2035,[175] and these figures arrive on the heels of estimates that gas reserves may hold upwards of one hundred years' worth of potentially cheap electricity.[176] Accordingly, gas is being seen as a "game-changer"[177]

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170. Felix Mormann, *Requirements for a Renewables Revolution*, 38 ECOLOGY L.Q. 903, 913 (2011), *available at* http://www.boalt.org/elq/documents/elq38_4_03_2012_0808.pdf.

171. Arthur Max, *Energy Markets: U.S. Shale Production Will Redraw Global Energy Map within 25 Years, IEA Predicts*, EE NEWS (Nov. 13, 2012), http://eenews.net/public/energywire/2012/11/13/1.

172. INT'L ENERGY AGENCY, *supra* note 70, at 3. According to a recent study by the Congressional Budget Office, carbon capture and storage ("CCS") is still too expensive to be commercially viable. *Federal Efforts to Reduce the Cost of Carbon Capture and Sequestration*, CONGRESSIONAL BUDGET OFFICE (June 2012), http://www. cbo.gov/publication/43357. By some estimates, a carbon price on the order of $65 per ton would be required to spur widespread deployment of CCS. Howard Herzog, *Scaling up Carbon Dioxide Capture and Storage*, ENERGY ECONOMICS 3 (2011), *available at* http://sequestration.mit.edu/pdf/Herzog_EnergyEconomics_Dec2010.pdf. At that rate renewables would be a more cost-effective option.

173. Kevin Doran and Adam Reed, *Natural Gas and Its Role in the U.S. Energy Endgame*, YALE ENV'T 360 (Aug. 13, 2012), http://e360.yale.edu/feature/natural_gas_role_in_us_energy_endgame/2561/.

174. CENTER FOR CLIMATE AND ENERGY SOLUTIONS, U.S. NATURAL GAS OVERVIEW OF MARKETS AND USES 1, 3 (2012), *available at* http://www.c2es.org/docUploads/natural-gas-markets-use.pdf.

175. INT'L ENERGY AGENCY, GOLDEN RULES, *supra* note 135, at 107.

176. ICF INT'L, *supra* note 150, at 1, 24.

177. *Natural Gas as a Game Changer*, WALL ST. J. (Mar. 26, 2012), http://online.wsj.com/article/SB10001424052702304636404577299682719190576.html.

and a "foundation fuel for . . . the energy future."[178] This reality has understandably left the future of renewables less certain and has raised concerns that unconventional gas will delay an inevitable transition to a more sustainable energy paradigm.[179] Given the urgent need for a rapid shift to emission-free energy sources, even minor delays to a renewables transition could derail emissions targets.

Despite this surge of cheap natural gas, renewables have demonstrated strong performance over the past few years. Roughly half of added power capacity in 2012 came from renewables—mostly wind.[180] Government subsidies under the 2009 American Recovery and Reinvestment Act have facilitated this growth.[181] Renewables incentives under this legislation have helped buffer construction costs while injecting money into projects like the smart grid.[182] In 2011, renewables contributed to 39 percent of added electric capacity[183] and represented approximately 11.8 percent of the United States's primary energy production.[184] Globally, net investment for renewable capacity impressively outstripped that for fossil fuels.[185] Renewables are forecast to see continued growth in the coming years;[186] the cardinal question is how strong they will become.

Even with this growth, the surplus of inexpensive gas has tempered renewables development. Some analysts are suggesting that the availability of inexpensive shale gas could diminish renewables' attractiveness and "erode solar economics."[187] Indeed, solar businesses worldwide witnessed record losses last year.[188] BP, as one example, recently decided to pull out of solar, announcing that the company has "thrown in the towel on solar."[189] At a recent energy conference, Jim Rogers, President and CEO of Duke Energy Corporation, echoed these concerns and

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178. Dave McCurdy, American Gas Association President's Discussion of the Impact of Low Natural Gas Prices on Infrastructure Development (Aired on E&E TV, Sept. 13, 2012) (transcript available at http://www.eenews.net/tv/transcript/1571).

179. Sergey Paltsev et al., *The Future of U.S. Natural Gas Production, Use, and Trade*, 39 ENERGY POL'Y 5309, 5320 (2011), *available at* http://ac.els-cdn.com/S0301421511004198/1-s2.0-S0301421511004198-main.pdf?_tid=d17d52ae-81e0-11e2-b55e-00000aab0f02&acdnat=1362081516_6869107477ab4a6 51acf822192d0d18a.

180. Philip Bump, *Nearly Half of New U.S. Power Capacity in 2012 Was Renewable—Mostly Wind*, GRIST (Jan. 18, 2013), http://grist.org/news/nearly-half-of-new-u-s-power-capacity-in-2012-was-renewable-mostly-wind/.

181. Kevin Eber, *Clean Energy Aspects of the American Recovery and Reinvestment Act*, RENEWABLE ENERGY WORLD.COM (Feb. 18, 2009), http://www.renewableenergyworld.com/rea/news/article/2009/02/clean-energy-aspects-of-the-american-recovery-and-reinvestment-act.

182. Bump, *supra* note 180.

183. *Id.*

184. Janet L. Sawin, *Green Growth Still Setting the Pace*, RENEWABLE ENERGY WORLD.COM (Oct. 18, 2012), http://www.renewableenergyworld.com/rea/news/article/2012/10/green-growth-still-setting-the-pace?page=2.

185. *Id.*

186. *IEA Sees Renewable Energy Growth Accelerating Over Next 5 Years*, INT'L ENERGY AGENCY (July 5, 2012), http://www.iea.org/newsroomandevents/pressreleases/2012/july/name,28200,en.html.

187. Krister Aanesen, et al., *Solar Power: Darkest Before Dawn*, MCKINSEY ON SEMICONDUCTORS (2012), at 90.

188. *Solar Firms to Bank on Rising Module Demand-McKinsey*, REUTERS (Apr. 17, 2012), http://www.reuters.com/article/2012/04/17/solar-companies-report-idUSL6E8FHAM620120417.

189. Jeff Brady, *BP Bows out of Solar, but Industry Outlook Still Sunny*, NPR (Mar. 7, 2013), http://www.npr.org/2013/03/07/173656739/bp-bows-out-of-solar-but-industry-outlook-still-sunny.

warned against "building too much gas," cautioning that "when gas is so cheap, there's no need for renewables."[190]

Indeed, energy investments are reflecting a shift toward natural gas. In Ohio, solar manufacturers are going out of business, and wind suppliers have laid off employees, although some of this activity could be contributed to the Great Recession.[191] While the state passed a law in 2008 requiring utilities to purchase twenty-five percent of their power from renewables by 2025, the Ohio Legislature is now considering revising this target.[192] Good Energies Capital, a New York-based renewable energy investment firm, recently changed its name to Bregal Energy while simultaneously broadening its energy portfolio to include shale gas.[193] In June 2012, Bregal increased investment in shale development in Pennsylvania.[194] The CEO of the firm explained that "early state renewable project development is challenging in the current environment," and while they plan to continue supporting a $5 billion off-shore wind development, they are investing with an eye toward shale.[195] Likewise, oil and renewables investor T. Boone Pickens is blaming cheap natural gas for his losses in wind investments.[196] For wind to be economically viable, Pickens noted, natural gas has to stand at six dollars per MMBtu, and currently it is around $2.33.[197] Energy experts are predicting gas will stand at four dollars for the foreseeable future.[198] Natural gas is also believed to be at least partly responsible for NextEra Energy's decision to cancel new wind power projects.[199]

Henry Warren, president of natural gas and electricity supplier Washington Gas Energy Services, holds a different opinion of the gas-renewables rivalry.[200] Warren believes that despite the glut and low price of natural gas, renewables will persevere.[201] Wind and solar infrastructure have continued to see strong growth, Warren explains, and clients remain interested in sustainability and corporate responsibility, which is helping "drive [] the dialogue [] about purchases of renewable energy."[202]

190. Saqib Rahim, *Cheap Fuel Transforms the Whole Climate and Energy Challenge, Experts Say*, E&E REPORTER, Apr. 12, 2012.

191. Jacob Wheeler & Keith Schneider, *Clean Energy Picture Dramatically Changed For Midwest, As U.S. Fossil Energy Boom Gathers Steam*, CIRCLE OF BLUE (Apr. 9, 2012), http://www.circleofblue.org/waternews/2012/world/clean-energy-picture-dramatically-changed-for-midwest-as-u-s-fossil-energy-boom-gathers-steam/.

192. *Hearings Open on Bill to Repeal Renewable Energy Standards (SB216)*, AIA OHIO, http://www.aiaohio.org/index.php?option=com_content&view=article&id=479:hearings-open-on-bill-to-repeal-renewable-energy-standards-sb216&catid=38:legislative-issues&Itemid=50 (last visited Feb. 28, 2013).

193. Peter Behr, *Energy Investor Shifts from Renewables to Shale*, UNITED NATIONS ENV'T PROGRAM (Aug. 22, 2012), available at www.unep.org/cpi/briefs/2012Aug23.

194. *Id.*

195. *Id.*

196. Rahim, *supra* note 190.

197. Behr, *supra* note 193.

198. *Id.*

199. *Shale Boom Reduces Producers' Profits, Kills Alternative Energy Projects*, ENV'T AND ENERGY DAILY (Jan. 17, 2012), http://www.eenews.net/Greenwire/2012/01/17/archive/12?terms=NextEra+energy+and+natural+gas+.

200. Harry Warren, Washington Gas Energy Services President's Discussion of the Impact of Natural Gas on Renewables (Aired on E&E TV, Sept. 25, 2012) (transcript available at http://www.eenews.net/tv/transcript/1579).

201. *Id.*

202. *Id.*

Amory Lovins and Jon Creyts of the Rocky Mountain Institute ("RMI") likewise suggest that "those who say cheap natural gas is killing alternatives" are "doing the math wrong."[203] They explain that when factoring in the cost of insuring against price volatility and other factors, natural gas is closer to six to eight dollars per one million British thermal units ("MMBtu")—making it more cost-competitive with solar and wind. An RMI report looking at the volatility of natural gas[204] underscores the risks that would accompany a massive upscale of infrastructure. Lovins and Creyts further expect that utility-scale renewables will be able to compete without subsidies within just a few years.[205] Naturally, this holds promise for RMI's robust renewables energy model for 2050, advanced in Amory Lovins' book *Reinventing Fire: Bold Business Solutions for the New Energy Era*.[206] The proposed model emphasizes energy efficiency and a tempered rise in natural gas (requiring a third less natural gas than current levels) coupled with a strong renewables portfolio.[207]

To achieve ambitious renewables targets, government initiatives will have to play an important role in attracting investment, accelerating technological advancements, and achieving desired renewables goals.[208] This will likely require reforms in the allocation of government subsidies. Global renewables subsidies reached eighty-eight billion in 2011, an increase of approximately twenty-four percent, and this growth is projected to rise to 240 billion by 2035. [209] While this amount suggests a leveling of the energy playing field, it remains less than half of the subsidy presently allocated for fossil fuels, which totaled $523 billion in 2011.[210] The IEA recognizes the distorting effect that fossil fuel subsidies have on energy markets.[211] In its Golden Rules model, the IEA emphasizes the role of policy in addressing the fossil-renewables rivalry.[212] In its estimates, the IEA remarks that global renewable sources of energy will not be substantially affected by the increased use of natural gas.[213] In the same breath, however, the IEA acknowledged that "an abundance of natural gas might diminish the resolve of governments to support low- and zero-carbon sources of energy."[214] The IEA reconciles these two seemingly at-odds positions by highlighting the necessary role of governments and policy to ensure that renewables remain economically attractive in the face of a surplus of inexpensive gas.[215]

203. Amory B. Lovins & John Creyts, *Hot Air About Cheap Natural Gas*, ROCKY MOUNTAIN INST. (Sept. 6, 2012), http://blog.rmi.org/blog_hot_air_about_cheap_natural_gas.

204. Lisa Huber, *Utility Scale Wind and Natural Gas Volatility: Uncovering the Hedge Value of Wind for Utilities and Their Customers*, ROCKY MOUNTAIN INST. (July 2012), http://www.rmi.org/Knowledge-Center/Library/2012-07_WindNaturalGasVolatility.

205. Lovins & Creyts, *supra* note 203.

206. AMORY B. LOVINS, REINVENTING FIRE: BOLD BUSINESS SOLUTIONS FOR THE NEW ENERGY ERA (2011).

207. *Id.*

208. INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK FACTSHEET 2012, *supra* note 70.

209. Arthur Max, *U.S. Shale Production Will Redraw Global Energy Map Within 25 Years, EIA Predicts*, (Nov. 13, 2012) http://www.eenews.net/energywire/2012/11/13/archive/1?terms=renewables+and+natural+gas.

210. *Id.*

211. INT'L ENERGY AGENCY, WORLD ENERGY OUTLOOK FACTSHEET 2012, *supra* note 70.

212. INT'L ENERGY AGENCY, GOLDEN RULES, *supra* note 135, at 80.

213. *Id.*

214. *Id.*

215. *Id.*

While natural gas is slated to play a major role in the future of American energy policy, the increasing attractiveness of renewables is challenging the fossil lock-in theory and offering a more optimistic outlook for renewables. The increasing cost-competitiveness of solar and wind underscores the viability of a high-penetration renewables model.

E. Solar

Solar is witnessing promising growth. Globally, installed solar capacity currently exceeding 65 gigawatts ("GW"), up from 4.5 GW in 2005, and projections estimate that global solar capacity will total 150 to 250 GW by 2020. [216] Solar photovoltaic ("PV") witnessed the fastest growth among renewable technologies between 2006 and 2011.[217] During this period, PV capacity grew by an average of fifty-eight percent annually, with concentrated solar power[218] ("CSP") and wind power not far behind—averaging thirty-seven percent and twenty-six percent respectively.[219] Energy analysts predict that global PV installation will increase fifty-fold from 2005 figures by 2020.[220] In the United States, approximately 1.3 GW of new utility-scale solar was added between 2010 and 2012, tripling solar capacity from 2009 figures.[221] Moreover, added solar capacity in the first quarter of 2013 amounted to over twice the amount added during this same period last year.[222] While this suggests good news for renewables, solar remains less than one percent of total installed United States power generation.[223]

Cost-competitiveness remains the pivotal issue for renewables, but costs are coming down.[224] The price of solar has steadily fallen at an annual rate of seven percent over the past three decades.[225] There has also been a marked decrease in the price of silicon—a major cost in solar manufacturing—which has lowered the price of photovoltaic and encouraged solar investment.[226]

These figures do not necessarily reflect the true value of solar relative to its fossil counterparts. One of the greatest advantages of renewables, and solar in par-

216. Aanesen, *supra* note 187.

217. REN21, RENEWABLES 2012 GLOBAL STATUS REPORT 2012 13 (2012), *available at* http://new.ren21.net/Portals/0/documents/activities/gsr/GSR2012.pdf.

218. Also referred to as "solar thermal."

219. REN21, *supra* note 217, at 13.

220. Aanesen, *supra* note 187, at 88.

221. *Natural Gas, Renewables Dominate Electric Capacity Additions in First Half 2012*, EIA (Aug. 20, 2012), http://www.eia.gov/todayinenergy/detail.cfm?id=7610.

222. *82% of New U.S. Electrical Capacity is Renewable Energy*, SUSTAINABLE BUS. NEWS, (Apr. 11, 2013), http: www.sustainablebusiness.com/index.cfm/go/news.display/id/24766.

223. GEOFF KEITH ET AL., THE HIDDEN COSTS OF ELECTRICITY: COMPARING THE HIDDEN COSTS OF POWER GENERATION FUELS 56 (2012), *available at* http://www.civilsocietyinstitute.org/media/pdfs/091912%20Hidden%20Costs%20of%20Electricity%20report%20FINAL2.pdf.

224. Aanesen, *supra* note 187, at 85.

225. Ramez Naam, *Smaller, Cheaper, Faster: Does Moore's Law Apply to Solar Cells?*, BLOGS.SCIENTIFICAMERICAN.COM (Mar. 16, 2011), http://blogs.scientificamerican.com/guest-blog/2011/03/16/smaller-cheaper-faster-does-moores-law-apply-to-solar-cells/.

226. JUSTIN MOLAVI, SUNNY DAYS: GOVERNMENT INCENTIVES WILL SUPPORT REVENUE GROWTH AS DEMAND HEATS UP 5–6, 8–9 (2011), *available at* http://www.aba.com/aba/documents/CommercialInsights/IBISWorld_Solar.pdf.

ticular, is that they produce minimal negative externalities.[227] For example, solar generates zero emissions—discounting manufacture and construction—thereby reducing environmental and public health burdens.[228] Difficulties in monetizing environmental and public health burdens from fossil fuel generation, like photochemical smog, acid deposition, and carbon emissions, makes evaluating the true costs of these fuels difficult.[229]

Another important consideration surrounding fossil generation relative to renewables is water use. Solar technologies generally consume little to no water.[230] While CSP technologies can require large quantities of water, photovoltaic and dry cooling systems use minimal water and technological advances are minimizing CSP's water footprint.[231] By contrast, fracking operations consume significant quantities of water, while imposing heightened risks to groundwater and surface water quantity and quality.[232] Water externalities for natural gas can add between 0.1 to 4.0 cents per kWh, and water replacement costs can take hundreds of years to match corresponding profits.[233] The low cost of water also provides little incentive for conservation. Power generation for natural gas, coal, and nuclear consumes up to 500 gallons per megawatt hour ("mWh"), with water costing on average one dollar per 1,000 gallons.[234] Taking into account these negative externalities, energy costs are invariably skewed.

Although negative externalities also accompany solar and other renewables, such as water, expensive and environmentally costly materials such as rare earth metals, and land use,[235] these costs are generally modest in comparison to their fossil counterparts.[236] Moreover, technological advances may help enhance solar's attractiveness and further minimize these externalities. New solar technologies, like the recently debuted Spin Cell, have emerged as champions of a new renewables age.[237] The architects behind Spin Cell are projecting levelized solar costs to fall to eight cents per kWh.[238] At this price, solar will become three times cheaper than its current rate. Moreover, the company anticipates that its technology will triple the

227. *See* U.S. DEP'T OF ENERGY, SOLAR POWER ENVIRONMENTAL IMPACTS AND SITING CHALLENGES 162 (2012), *available at* http://www1.eere.energy.gov/solar/pdfs/47927.pdf.

228. See *id.*

229. SMIL, *supra* note 163.

230. *Id.* at 165–66.

231. *Id.*

232. U.S. GOV'T ACCOUNTABILITY OFFICE, OIL AND GAS: INFORMATION ON SHALE RESOURCES, DEVELOPMENT, AND ENVIRONMENTAL AND PUBLIC HEALTH RISK 38 (2012), *available at* http://www.gao.gov/assets/650/647791.pdf; KEITH ET AL., *supra* note 223, at 8.

233. *See* Katie Phillips, *What is the True Cost of Hydraulic Facturing? Incorporating Negative Externalities into the Cost of America's Latest Energy Alternative*, 2 J. OF STUDENT RES. IN ENVTL. SCI. AT APPALACHIAN 40, 46 (2012), *available at* http://pimlico.phys.appstate.edu/JSRESA/phillips.2-1-eprint-FINAL.pdf.

234. Nathan Mee & Marc Miller, *Here Comes the Sun: Solar Power Parity with Fossil Fuels*, 36 WM. & MARY ENVTL. L, & POL'Y REV. 119, 135 (2011).

235. *See generally* Robert Glennon & Andrew M. Reeves, *Solar Energy's Cloudy Future*, 1 ARIZ. J. OF ENVTL. L. AND POL'Y. 91 (2010).

236. *Id.*

237. The New York Times, *On Our Radar: A Spinning Solar Cell*, GREEN (Jan. 25, 2013), http://green.blogs.nytimes.com/2013/01/25/on-our-radar-a-spinning-solar-cell/.

238. *Id.*

size of the present United States solar market.[239] Its conical design captures more heat with the same amount of surface area and uses silicon PV as opposed to more expensive materials like those used for concentrated solar panels.[240] Additionally, it self-cools as it spins.[241] Technological breakthroughs like these substantiate claims of renewables' growing economic attractiveness.

F. Wind

Like solar, wind generation has seen strong growth in recent years. As of recently, the United States is leading the global wind power market, with General Electric at the helm with 15.5 percent of the global market share.[242] In the United States, wind power has increased from approximately six billion kWh in 2000 to nearly 120 billion kWh in 2011,[243] accounting for thirty-two percent of electric generating capacity additions.[244] In Iowa and South Dakota, approximately twenty-five percent of power generation comes from wind, and Texas currently "boasts more wind power than any other state" according to recent figures.[245] With these additions, total wind power capacity stood at forty-seven GW at the end of 2011.[246] Wind energy is also becoming one of the fastest growing American manufacturing sectors. At least 472 American factories currently supply the industry, up from as few as thirty in 2004, according to recent findings by the nonpartisan Congressional Research Service.[247]

While the future of wind energy policy and subsidies is unclear, unsubsidized wind is already becoming cost competitive in regions where the cost of natural gas exceeds six dollars per MMBtu.[248] Part of the reason for wind energy's growing attractiveness is lowered production costs. Wind turbine prices have dropped twenty to thirty percent since 2008[249] and have been declining an average of fourteen

239. David Roberts, *Solar Power Cheaper than Coal: One Company Says It's Cracked the Code*, GRIST (Jan. 25, 2013), http://grist.org/business-technology/solar-power-cheaper-than-coal-one-company-says-its-cracked-the-code/.

240. *Id.*

241. *Id.*

242. NAVIGANT RESEARCH, WORLD MARKET UPDATE 2012: INTERNATIONAL WIND ENERGY DEVELOPMENT FORECAST 2013-2017 (2013), *available at* http://www.navigantresearch.com/research/world-market-update-2012.

243. ENERGY INFO. ADMIN., U.S. DEPARTMENT OF ENERGY, ANNUAL ENERGY REVIEW 2011 (2012), http://www.eia.gov/totalenergy/data/annual/pdf/aer.pdf .

244. U.S. DEP'T OF ENERGY, 2011 WIND TECHNOLOGIES MARKET REPORT 4 (Aug. 2012), *available at* http://www1.eere.energy.gov/wind/pdfs/2011_wind_technologies_market_report.pdf.

245. *Wind Now 10% of Electricity in Nine States, Over 20% in Iowa, South Dakota*, AM. WIND ENERGY ASS'N (Mar. 15, 2013), http://www.awea.org/learnabout/publications/wew/loader.cfm?csModule=security/getfile&pageid=21884.

246. *Id.* at iii.

247. CONGRESSIONAL RESEARCH SERV., U.S. WIND TURBINE MANUFACTURING: FEDERAL SUPPORT FOR AN EMERGING INDUSTRY 14 (2011).

248. Robert S. Eshelman, *Tough Times Ahead for Wind Industry, Regardless of Tax Credit Renewal – Analyst*, GOVERNORS' WIND ENERGY COALITION (Oct. 9, 2012), http://www.governorswindenergycoalition.org/?p=3543; Dan Seif, *Natural Gas Boom Won't Stall Renewables*, ROCKY MOUNTAIN INST. (Feb. 16, 2012), http://blog.rmi.org/natural_gas_boom_wont_stall_us_renewables.

249. Brad Plumer, *The Rise—and Possible Fall—of U.S. Wind Power*, WASH. POST (Aug. 14, 2012, 4:17 PM), http://www.washingtonpost.com/blogs/wonkblog/wp/2012/08/14/the-rise-and-possible-fall-of-u-s-wind-power-in-five-charts/.

percent annually since the mid-1980s.[250] If prices continue to drop at this rate, wind power could directly compete in certain areas with wholesale natural gas by 2016, the year at which projections forecast gas to sell around four dollars per MMBtu.[251]

Offshore wind holds enormous potential, with government statistics suggesting that approximately 900,000 MW—roughly the total of installed United States electricity capacity—exists within fifty miles of the United States coastline.[252] Interestingly, turbine efficiency is shown to improve in tandem with the frequency the technology is used, which is to say, an energy model that embraces wind with the same gusto and enthusiasm shown shale could improve wind performance.[253] It stands to reason that if even small segments of wind development are siphoned away in favor of natural gas, the rate of transition and efficiency will be impaired.

Wind generation has not escaped the market impact of cheap natural gas. Cutbacks in American wind investments presage tougher times for wind's immediate future, according to Bloomberg analyst Ethan Zindler.[254] Cheap natural gas and decreased demand at the state level are largely to blame.[255] Zindler notes that "if natural gas were trading where it was three or four years ago and wind [were] as cheap as it is now, wind would actually be . . . doing very well against natural gas, in many cases competing and beating natural gas."[256] Bloomberg is projecting minimal investment in wind construction for 2013 and anticipates a decline in the overall sector in the next three years. [257]

When it comes to cost comparison, however, the value of wind—like solar—is further reflected in its economic and environmental benefits. After human health and environmental factors are accounted for, wind is cheaper than natural gas.[258] A study examining the relative costs of these two fuels found that the negative externalities of air pollution and climate change added approximately two to twelve cents per kWh for natural-gas-fired generation.[259] Once these negative externalities were internalized, natural gas rose to approximately 11.7–20.5 cents per kWh.[260] These numbers exceed the cost of onshore wind, which stands at approximately 10.96 cents per kWh.[261]

Despite the less optimistic overtures for wind and solar, renewables are becoming increasingly cost-competitive—not to mention environmentally imperative. This combination lends itself to policies embracing renewables as the backbone of the next United States energy model.

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250. Seif, *supra* note 248.
251. *Id.*
252. BENJAMIN SOVACOOL, THE DIRTY ENERGY DILEMMA: WHAT'S BLOCKING CLEAN POWER IN THE UNITED STATES 95 (2008).
253. CHRISTOPHER COOPER & BENJAMIN K. SOVACOOL, RENEWING AMERICA: THE CASE FOR FEDERAL LEADERSHIP ON A NATIONAL RENEWABLE PORTFOLIO STANDARD (RPS) 37 (2007).
254. Eshelman, *supra* note 248.
255. *Id.*
256. *Id.*
257. *Id.*
258. McCubbin & Sovacool, *supra* note 156, at 86.
259. *Id.*
260. *Id.* at 92.
261. *Id.*

G. The Future Energy Mix

With increasingly optimistic data on renewables, anything short of a large-scale investment in renewables poses an impractical and high-risk energy model—not only from a climate standpoint, but also economically. Indeed, nearly ninety-three percent of domestically recoverable energy is tied up in renewables like wind, geothermal, solar and biomass resources—over 46,800 times the rate of annual American energy consumption.[262] This is not to say that natural gas should not play a role in the nation's energy portfolio. On the contrary, a high penetration renewables scenario is compatible with carefully executed natural gas development.[263] For one, both renewables and natural gas serve the same end markets: transportation, industry, residential and commercial, and electricity.[264] Even in scenarios with low electricity load growth, zero added nuclear or carbon capture and sequestration, and twenty percent renewables, if emissions are to be capped at 1,500 tons by 2030, as some targets have set, natural gas may prove an important supplement for improving reliability and flexibility in power generation.[265] David McCurdy, president of the American Gas Association, sees natural gas as "a great fuel to work in conjunction with other alternatives [like] wind and solar."[266] Because solar and wind respond to local climate conditions, thereby generating intermittent energy flow, natural gas can help support a renewables paradigm. The issue again boils down to scale as many, like McCurdy, see natural gas as the "backbone" of the future energy model.[267]

In addition to solar and wind, other alternatives including geothermal, hydroelectric, and biomass hold potential for reducing carbon emissions. The levelized costs[268] of electricity for biomass, geothermal, hydroelectric, and wind all fall below the price of gas and oil.[269] Importantly, these alternative sources, unlike solar and wind, can provide baseload generation, which allows for greater reliability and continued energy flow.[270] The intermittency of solar and wind generation can thus be paired with these baseload systems, alongside energy efficiency technologies like smart meters, to improve the continuity of renewables power generation.[271]

Statistics for renewables suggest that a renewables-based energy model is an increasingly viable and stable route for United States energy policy.[272] Any number

262. *See* SOVACOOL, *supra* note 252, at 17.

263. *See* Huber, *supra* note 204, at 4.

264. *See* Anne M. Stark, *Americans Use More Efficient and Renewable Energy Technologies*, LAWRENCE LIVERMORE NAT'L LAB., https://www.llnl.gov/news/newsreleases/2012/Oct/NR-12-10-08.html (last visited Feb. 28, 2013).

265. ASPEN ENVTL. GROUP, *supra* note 154, at 23.

266. McCurdy, *supra* note 178.

267. *Id.*

268. Levelized costs calculate the capital cost plus the cost of fueling, operating, maintenance and decommissioning. Benjamin Sovacool & Charmaine Watts, *Going Completely Renewable: Is it Possible (Let Alone Desirable)?*, 22 ELEC. J. 97–98 (2011).

269. *See id.* tbl.2. at 98.

270. *Id.* at 97.

271. *Id.*

272. *See Renewable Electricity Futures Study*, NAT'L RENEWABLE ENERGY LAB. (Mar. 2013), http://www.nrel.gov./analysis/re_futures ("Renewable electricity generation from technologies that are commercially available today, in combination with a more flexible electric system, is more than adequate to supply 80% of total U.S. electricity generation in 2050 while meeting electricity demand on an hourly basis in every region in the country.").

of unknowable variables could throw a wrench into the projected profitability of natural gas, and price and policy may ultimately prove fatal for natural gas. As the cost of solar and wind continues to decline, falling in step with Moore's Law[273] and technological advancements, natural gas could lose its market edge. Moreover, changes in policy, such as a national renewables portfolio standard[274] or if externalized costs are factored into the equation, renewables will comfortably outcompete natural gas.

As the energy landscape confronts two lock-in energy landscapes, it is becoming increasingly apparent that a renewables-based energy model is not only compatible with market projections, but also indispensable to achieving a stable climate.

III. OFF-RAMPS ON THE SHALE GAS HIGHWAY

Natural gas will undoubtedly play a significant role in the nation's energy future. It is in many ways preferable to coal and oil from an environmental, economic, and national security perspective.[275] When it comes to dealing with the climate crisis, however, the question is whether gas will be part of the solution or part of the problem. Having a climate policy that explicitly reduces emissions is likely to have a far bigger influence on the future course of climate change than how much cheap natural gas is available. What follows is a brief description of polices that could provide off-ramps to prevent another carbon lock-in.

A. Avoiding a Fiscal and Climate Cliff through a Graduated Carbon Tax

Admittedly, a carbon tax is not in the cards right now. But sooner or later a price must be put on carbon, and a well-designed carbon tax could provide a range of benefits to the nation. In the debate leading up the "fiscal cliff" legislation last February, the idea of a carbon tax looked like it was gaining some political traction as a way of addressing the national debt, which currently stands at over $16 trillion.[276] Congress floated a number of carbon-tax proposals, though none ultimately

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273. Moore's Law is an accepted axiom for determining the rate of technological progress relative to size and cost. David E. Liddle, *The Wider Impact of Moore's Law*, IEEE SOLID STATE CIRCUITS (Sept. 2006), http://www.ieee.org/portal/site/sscs/menuitem.f07ee9e3b2a01d06bb9305765bac26c8/index.jsp?&p Name=sscs_level1_article&TheCat=2165&path=sscs/06Sept&file=Liddle.xml.

274. Congress has repeatedly tried to pass a national RPS. With the departure of former Senator Jeff Bingaman of New Mexico, who was an ardent champion of the issue, prospects for lean energy legislation are unclear. The Chair of the Senate Environment and Public Works Committee, Senator Barbara Boxer of California has formed a "climate change caucus" to push climate and energy legislation, but without the active support of the White House, nothing is likely to happen in the foreseeable future. Ben Geman, *Sen. Boxer Announces Plan to Form 'Climate Change Caucus'*, THE HILL (Dec. 11, 2012), http://thehill.com/blogs/e2-wire/e2-wire/272273-sen-boxer-to-form-climate-change-caucus. Even if a bill could pass the Senate, it would face even stiffer opposition in the Republican-controlled House.

275. *See, e.g.*, *Natural Gas: Earth and Sky Friendly*, NAT'L FUEL, http://www.nationalfuelgas.com/natural_gas_environment.aspx (last visited Feb. 28, 2013). *But see* Abraham Lustgarten, *Climate Benefits of Natural Gas May Be Overstated*, PROPUBLICA.ORG (Jan. 25, 2011, 7:34 AM), http://www.propublica.org/article/natural-gas-and-coal-pollution-gap-in-doubt.

276. *Debt to the Penny and Who Holds It*, TREASURY DIRECT, http://www.treasurydirect.gov/NP/BPDLogin?application=np (last visited Feb. 28, 2013).

came to a vote.[277] In a timely report, the Brookings Institute recommended that Congress and the President "should implement a $20 per ton, steadily increasing carbon excise fee that would discourage carbon dioxide emissions while shifting taxation onto pollution, financing energy efficiency ("EE") and clean technology development, and providing opportunities to cut taxes or reduce the deficit."[278] Brookings explained how such a tax would help curb emissions, improve the nation's balance sheet, and stimulate job-creation and economic renewal.[279]

Many economists and conservative politicians consider an upstream, graduated tax on carbon content of all fossil fuels—coal, oil, and gas—to be a more efficient and simpler means of pricing carbon.[280] This approach could not only garner bi-partisan support, but may be preferable to the complex and contentious "cap and trade" regime that failed in the 112th Congress.[281] Of course, crafting a bill that could pass both houses of Congress, especially the House of Representatives, seems like a pipe dream at the moment; but, as the old saying goes, politics is the art of the possible. As the pressure mounts to find solutions to the debt crisis, there may be an opportunity to do something about the climate crisis at the same time.[282]

There are many different models for a carbon tax or fee. One that might appeal to conservative members of Congress would be "revenue neutral." This would mean that the government would retain little, if any, of the tax revenues raised by taxing carbon emissions. Instead, "[t]he vast majority of the revenues would be returned to the public, with, perhaps, a very small amount utilized to mitigate the otherwise negative impacts of carbon taxes on low-income energy users."[283] British Columbia, which has had a revenue-neutral carbon tax since 2008, offers a model for how the tax can work.[284] Because the tax is used to reduce taxes for individuals and businesses, British Columbia's corporate income tax rate dropped to ten percent down from twelve percent.[285] "Personal income taxes for people earning less than $119,000 per year are now the lowest in Canada, and there are targeted rebates

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277. Sarah Harmon, *Discussion of the Carbon Tax Resurfaces as the Fiscal Cliff Looms*, GEO. INT'L ENVTL. L. REV. (Dec. 3, 2012), http://gielr.wordpress.com/2012/12/03/discussion-of-the-carbon-tax-resurfaces-as-the-fiscal-cliff-looms/.

278. MARK MURO & JONATHAN ROTHWELL, INSTITUTE A MODEST CARBON TAX TO REDUCE CARBON EMISSIONS, FINANCE CLEAN ENERGY TECHNOLOGY DEVELOPMENT, CUT TAXES, AND REDUCE THE DEFICIT 3 (2012), *available at* http://www.brookings.edu/~/media/research/files/papers/2012/11/13%20federalism/13%20carbon%20tax.pdf.

279. *Id.*

280. *Id.* at 4.

281. *See* Mark Drajem, *Cap-and-Trade Failure Aided U.S. to Cut Carbon Emissions*, BLOOMBERG (Oct. 24, 2012, 9:00 PM), http://www.bloomberg.com/news/2012-10-25/cap-and-trade-failure-aided-u-s-to-cut-carbon-emissions.html.

282. Thomas L. Friedman, *It's Lose-Lose vs. Win-Win-Win-Win-Win*, N.Y. TIMES (Mar. 16, 2013). Friedman advocates a tax of $25 per ton of CO_2 that would generate $125 billion per year in revenues. He recommends using forty-five percent of the revenue to pay down the debt and avoid divisive cuts to Medicare and Social Security; another forty-five percent to reducing corporate and income taxes; and the balance of ten percent in rebates to low-income taxpayers. He argues that such a tax would add about twenty-one cents per gallon of gasoline and about 1.2 cents per kilowatt-hour of electricity. *Id.* There are many other models for how a tax might be designed and spent. The point is to start the conversation.

283. *Introduction*, CARBON TAX CENTER (Dec. 12, 2012), http://www.carbontax.org/introduction/.

284. *Myths and Facts About the Carbon Tax*, BRITISH COLUMBIA MINISTRY OF FINANCE, http://www.fin.gov.bc.ca/tbs/tp/climate/A6.htm (last visited Mar. 18, 2013).

285. *Id.*

for low-income and rural households."[286] This is all coinciding with a carbon tax rate that recently went from twenty-five to thirty dollars per ton.[287]

According to a study by MIT, a carbon tax starting at twenty dollars per ton and rising at four percent annually per year, would raise on average $150 billion a year over a ten-year period. The tax would additionally reduce carbon emissions fourteen percent below 2006 levels by 2020 and twenty percent below 2006 levels by 2050.[288] Based on Australia's experience with a $23.50 per ton carbon tax, it does not appear that there would be any significant economic consequences at this rate. An analysis by the Australian government found that the fee would increase consumer prices by just one percentage point during the first five years of implementation and have little effect after that.[289] The study did show that short-term impacts would be heavier on low-income households, requiring some form of rebate to offset the regressive nature of energy taxes.[290]

However, to achieve the scale of carbon reductions that science says is necessary,[291] "carbon pricing mechanisms need to be paired with direct research, development, and demonstration ["RD&D"] investments in order to overcome carbon lock-in and induce the clean tech innovation needed to dramatically lower carbon emissions."[292] Price alone will not unlock innovative technologies and allow them to scale, at least not prices that are politically acceptable.

Under the Brookings proposal, the first $30 billion of tax revenue would be set aside annually for clean energy and energy efficiency related RD&D and technology deployment.[293] This sum reflects Brookings's estimation of how much the government would need to spend on clean energy RD&D, beyond industry investment, to allow energy to catch up with RD&D in other comparable industries.[294] Brookings's model would allocate approximately $120 billion a year to tax cuts and deficit reduction as well as rebates to affected low-income households, as determined by Congress and the President.[295] Congress could also use the excess revenue to reduce a variety of taxes on individuals and corporations.[296]

In a report issued in September 2012, the Congressional Research Service (CRS) found that a carbon tax "would help reduce GHG emissions contributing to

286. Yoram Bauman & Shi-Ling Hsu, *The Most Sensible Tax of All*, N.Y. TIMES (July 4, 2012), http://www.nytimes.com/2012/07/05/opinion/a-carbon-tax-sensible-for-all.html.

287. *How the Carbon Tax Works*, BRITISH COLUMBIA MINISTRY OF FINANCE, http://www.fin.gov.bc.ca/tbs/tp/climate/A4.htm (last visited Mar. 18, 2013).

288. SEBASTIAN RAUSCH & JOHN REILLY, CARBON TAX REVENUE AND THE BUDGET DEFICIT: A WIN-WIN-WIN SOLUTION? 6, 17, *available at* http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt228.pdf.

289. COMMONWEALTH OF AUSTRALIA, STRONG GROWTH, LOW POLLUTION: MODELING A CARBON TAX 136 (2012), *available at* http://cache.treasury.gov.au/treasury/carbonpricemodelling/content/report/downloads/Modelling_Report_Consolidated.pdf.

290. *Id.* at 137.

291. In its Fourth Assessment Report, the Intergovernmental Panel on Climate Change said the industrialized nations of the world would need to reduce CO_2 emissions by eighty to ninety percent by 2050. CLIMATE CHANGE 2007: SYNTHESIS REPORT, 5. THE LONG-TERM PERSPECTIVE, *available at* http://www.ipcc.ch/publications_and_data/ar4/syr/en/spms5.html

292. MURO & ROTHWELL, *supra* note 278, at 3.

293. *Id.* at 4.

294. *Id.*

295. *Id.* at 5.

296. *Id.*

climate change and ocean acidification, and tax revenues could support a range of policy objectives, including deficit reduction."[297] According to the report:

> [A] tax rate of $20 per metric ton of CO2 would generate approximately $88 billion in 2012, rising to $144 billion by 2020 . . . . This estimated revenue source would reduce the 10-year budget deficit by 50%, using the 2012 baseline projection of the Congressional Budget Office (CBO). However, under CBO's alternative fiscal scenario, the same carbon tax would reduce the 10-year budget deficit by about 12%.[298]

CRS cautioned that there were a number of policy considerations and trade-offs to be considered. For one, CRS notes that adjustments would have to be made to deal with disproportionate impacts on lower-income households and carbon-intensive businesses exposed to trade impacts.[299] CRS also noted that:

> A carbon tax would discourage pollution that imposes costs on others who do not necessarily benefit from the polluting activity. These may include future generations that bear the dislocations of climate change, or fishery sectors in developing countries that experience lower yields in acidified oceans.[300]

One danger of pursuing a carbon tax is that it might prompt Congress to repeal the EPA's authority to regulate GHG emissions under the Clean Air Act and/or eliminate subsidies and incentives like the Production Tax Credit for renewables.[301] These trade-offs are neither justified nor wise and would have to be strenuously resisted. Immediate reduction in emissions is necessary, and the EPA must be able to fully utilize its authority under the CAA to make progress toward that goal. Moreover, a modest carbon tax alone is not enough to incentivize the rapid deployment of renewables that is necessary. A combination of carrots and sticks is required.

B. Leveling the Playing Field for Gas and Renewables

There are three ways to accomplish this. First, federal subsidies for gas should be eliminated or phased out. As a mature energy source capable of generating billions in investment capital and profits, gas no longer needs, and the nation can no longer afford, these subsidies. The Environmental Law Institute has issued a report detailing a number of tax breaks and other incentives that cost the nation billions in foregone revenues each year.[302] In the fiscal year 2010 budget, the Obama Admin-

297. *Id.* at 31.

298. CONGRESSIONAL RESEARCH SERV., CARBON TAX: DEFICIT REDUCTION AND OTHER CONSIDERATIONS (2012), *available at* http://www.fas.org/sgp/crs/misc/R42731.pdf.

299. *Id.* at 31–32.

300. *Id.* at 19.

301. David Roberts, *10 Reasons a Carbon Tax is Trickier Than You Think*, GRIST (Nov. 19, 2012), http://grist.org/climate-energy/ten-reasons-a-carbon-tax-is-trickier-than-you-think/.

302. ENVTL. L. INST., ESTIMATING U.S. GOV'T SUBSIDIES TO ENERGY SOURCES: 2002–2008 3 (2009). The study found that "[t]he federal government provided substantially larger subsidies to fossil fuels than to renewables. Subsidies to fossil fuels—a mature, developed industry that has enjoyed government

istration proposed the elimination of many of these subsidies, but Congress failed to act.[303] The independent think tank Resources for the Future concluded that "the proposed elimination of oil and gas subsidies will have slight effects on United States oil and natural gas markets, energy security, and economic activity."[304]

Second, wind and solar technologies, as they are relatively new and would require a boost to penetrate a fossil fuel-dominated market, should receive federal subsidies and investments in R&D. The most important of these boosts is the production tax credit ("PTC"), which was set to expire at the end of 2012 but has been extended for another year.[305] The PTC provides a 2.2 cent per kilowatt-hour tax credit for the first ten years of electricity production from utility-scale turbines.[306] According to some analysts, the PTC is largely responsible for the development of almost four gigawatts of wind energy in the first ten months of 2012.[307] The PTC has also helped lower development costs for wind farms in the past four years.[308]

Third, the environmental costs of fracking must be internalized in the price of gas. Fracking gives rise to a number of costly externalities. In addition to the methane released during natural gas production, drilling also emits a number of air pollutants, including $PM_{2.5}$, SO_2, NOX, VOCs and air toxics.[309] Drilling equipment is typically powered by large diesel engines, which emit substantial quantities of $PM_{2.5}$.[310] Emissions are considerable during the drilling and fracking of deep wells or in large fields where multiple drilling operations occur simultaneously.[311] Heavy duty diesel trucks must also deliver large quantities of water, sand, and other chemicals for fracking.[312] EPA estimates that water deliveries alone account for 1,660 truck trips per fracking event, leading to significant emissions of diesel air pollutants.[313] Pits used as waste repositories for wastewater and other waste materials are

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support for many years—totaled approximately $72 billion over the study period, representing a direct cost to taxpayers." *Id.*

303. *See* ROBERT PIROG, CONGRESSIONAL RESEARCH SERVICE, OIL AND NATURAL GAS INDUS. TAX ISSUES IN THE FY2013 PROPOSAL 1 (2012).

304. MAURA ALLAIRE & STEPHEN BROWN, RESOURCES FOR THE FUTURE, ELIMINATING SUBSIDIES FOR FOSSIL FUEL PRODUCTION: IMPLICATIONS FOR U.S. OIL AND NATURAL GAS MARKETS (2009), *available at* http://350ma.org/wp-content/uploads/2012/09/Resources-for-Future-report.pdf.

305. *Production Tax Credit Extended by Congress*, NAT'L RENEWABLE ENERGY LAB. (Jan. 1, 2013), http://www.nrel.gov/wind/news/2013/2067.html.

306. *Production Tax Credit for Renewable Energy*, UNION OF CONCERNED SCIENTISTS, http://www.ucsusa.org/clean_energy/smart-energy-solutions/increase-renewables/production-tax-credit-for.html (last revised Jan. 4, 2013).

307. Noah Ginsburg, *Modest Steps Could Add up to Big Success for Clean Energy in 2013*, ACORE BLOG, http://acore.org/posts/2849-small-steps-to-success-in-2013 (last visited Mar. 6, 2013).

308. *Id.*

309. Press Release, American Wind Energy Association, Congress Extends Wind Energy Tax Credits for Projects that Start in 2013 (Jan. 1, 2013), *available at* http://www.awea.org/newsroom/pressreleases/congressextendswindptc.cfm.

310. M.J. BRADLEY & ASSOC. LLC, AMERICAN LUNG ASSOCIATION ENERGY POLICY DEVELOPMENT: ELECTRICITY GENERATION BACKGROUND DOCUMENT 13 (2013), *available at* http://www.lung.org/healthy-air/outdoor/resources/electricity-generation.pdf.

311. NAT'L ACAD. OF SCI., HIDDEN COSTS OF ENERGY: UNPRICED CONSEQUENCES OF ENERGY PRODUCTION AND USE 112 (2010).

312. *See* Jack Healy, *For Farms in the West, Oil Wells are Thirsty Rivals*, N.Y. TIMES (Sept. 5 2012), http://www.nytimes.com/2012/09/06/us/struggle-for-water-in-colorado-with-rise-in-fracking.html?pagewanted=allhttp://www.nytimes.com/2012/09/06/us/struggle-for-water-in-colorado-with-rise-in-fracking.html?pagewanted=all.

313. OFFICE OF RESEARCH AND DEV., ENVIRONMENTAL PROTECTION AGENCY, DRAFT PLAN TO STUDY THE POTENTIAL IMPACTS OF HYDRAULIC FRACTURING ON WATER RESOURCES 55 (2011), *available at* http://yosemite.epa.gov/sab/sabproduct.nsf/0/D3483AB445AE61418525775900603E79/$File/

also significant sources of air pollution from the volatilization of organic compounds.[314]

Fracking also consumes vast quantities of water. In 2010, EPA estimated that fracking shale wells can use anywhere from two to ten million gallons of water per well.[315] This water is commonly extracted from on-site surface or groundwater supplies.[316] Such huge water withdrawals raise serious concerns about the impacts on ecosystems and drinking water supplies, especially in areas under drought conditions, areas with low seasonal flow, locations with already stressed water supplies, or locations with waters that have sensitive aquatic communities.[317] Regulation of water withdrawals remains weak in many areas of the United States, and emerging water-energy confrontations surrounding natural gas production will continue to pose risks to United States water supplies absent revised water withdrawal policy and reforms.

In addition to consuming large quantities of water, natural gas production also puts water supplies at risk of contamination. Groundwater contamination can occur during unconventional gas production as a result of drilling, ruptured well casings, failed cement jobs, or surface spills of fracking fluids or wastewater. Fracking fluids can contain chemical additives and naturally occurring materials such as brines, metals, radionuclides, and hydrocarbons; however, whether the fracking process itself can directly cause groundwater contamination is still a matter of scientific debate.[318] Recently, the EPA released a preliminary study linking fracking to the contamination of several wells in the town of Pavillion, Wyoming, where extensive fracking has taken place.[319] Scientists from Duke University released a report last year documenting what they called "systematic evidence for methane contamination of drinking water wells associated with shale-gas extraction" in the Marcellus and Utica shale formations in Pennsylvania and New York.[320] In 2007, after one home exploded and nineteen others had to be evacuated, the Ohio Department of Natural Resources determined that migration of natural gas from a fracked well

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Draft+Plan+to+Study+the+Potential+Impacts+of+Hydraulic+Fracturing+on+Drinking+Water+Resources-February+2011.pdf.

314. *See* REBECCA HAMMER & JEANNE VANBRIESEN, NATURAL RESOURCES DEFENSE COUNCIL, IN FRACKING'S WAKE: NEW RULES ARE NEEDED TO PROTECT OUR HEALTH AND ENVIRONMENT FROM CONTAMINATED WASTEWATER 12 (2012), *available at* http://www.nrdc.org/energy/files/Fracking-Wastewater-FullReport.pdf.

315. David M. Kargbo et al., *Natural Gas Plays in the Marcellus Shale: Challenges and Potential Opportunities*, 44 ENVIRON. SCI. TECHNOL. 5679, 5681 (2010).

316. *See* Healy, *supra* note 312.

317. Kargbo, *supra* note 315.

318. MIT, THE FUTURE OF NATURAL GAS (2011), *available at* http://mitei.mit.edu/system/files/NaturalGas_Report.pdf.

319. *See generally*, U.S. ENVTL. PROT. AGENCY, PAVILLION: GROUNDWATER INVESTIGATION (2011) *available at* http://www.epa.gov/region8/superfund/wy/pavillion/. In response to heavy criticism from industry, EPA agreed to retest the wells and split the samples for analysis. On January 11, 2013 EPA Region 8 announced that it was extending the public comment period on its research and sampling program until September 13, 2013. *Id.*

320. STEPHEN G. OSBORN ET AL., PNAS, METHANE CONTAMINATION OF DRINKING WATER ACCOMPANYING GAS-WELL DRILLING AND HYDRAULIC FRACTURING (William H. Schlesinger ed., 2011), *available at* http://www.nicholas.duke.edu/cgc/pnas2011.pdf. The researchers found that, at least in some cases, this methane had a chemical signature closer to that of methane from the deep shale than from shallower subsurface layers. *Id.*

caused gas to invade the overlying aquifers.[321] The gas was then discharged through local water wells, ultimately leading to the conditions that caused the explosion.[322] The EPA is currently conducting a national investigation into whether fracking poses a risk to groundwater resources. The results are not due to be released until 2014.

Fracking is currently exempt from regulation under the Safe Drinking Water Act (except when diesel is used as a proppant).[323] This loophole needs to be closed. Fracking waste is also generally exempt from regulation as hazardous waste under subtitle C of the Resource Conservation and Recovery Act.[324] Fracking wastes are also covered by the "petroleum exemption" under CERCLA.[325] These exemptions should be revisited following EPA's comprehensive fracking study. Discharge of wastewater from fracking is subject to regulation under the CAA, but the EPA has been slow to adopt regulations setting effluent standards.[326] Disposal of fracking wastewater, which can contain radionuclides and other toxic chemicals, into municipal sewage treatment plants that are ill-equipped to handle such wastes has caused serious problems in some areas.[327]

Explosions, blowouts and earthquakes have all been associated with fracking operations.[328] Better siting and land use controls are needed, such as setbacks from residences, commercial areas, schools and other public places.[329] Baseline studies

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321. OHIO DEP'T OF NATURAL RES., REPORT ON THE INVESTIGATION OF THE NATURAL GAS INVASION OF AQUIFERS IN BAINBRIDGE TOWNSHIP OF GEAUGA COUNTY, OHIO 1–4 (2008), *available at* http://www.dnr.state.oh.us/Portals/11/bainbridge/report.pdf.

322. *Id.*

323. 42 U.S.C. § 1421 (d)(1) (2012).

324. U.S. ENVTL. PROT. AGENCY, EXEMPTION OF OIL AND GAS EXPLORATION AND PRODUCTION WASTES FROM FEDERAL HAZARDOUS WASTE REGULATIONS 10 (2002), *available at* http://www.epa.gov/epawaste/nonhaz/industrial/special/oil/oil-gas.pdf. Some wastes, such as unused fracturing fluids or acids, are categorized as "non-exempt." *Id.* at 11.

325. 42 U.S.C.A. § 9601(14) (West 2012). "The term [hazardous substance] does not include petroleum, including crude oil or any fraction thereof which is not otherwise specifically listed or designated as a of this paragraph, and the term does not include natural gas, natural gas liquids, liquefied natural gas, or synthetic gas usable for fuel (or mixtures of natural gas and such synthetic gas." *Id.*

326. In October 2011, as part of the CWA section 304(m) planning process, EPA announced a schedule to develop standards for wastewater discharges produced by natural gas extraction from underground coalbed and shale formations. EPA is in the process of gathering data, consulting with stakeholders, and soliciting public comment. A proposed rule for shale gas is due in in 2014. *Natural Gas Extraction – Hydraulic Fracturing*, EPA, http://www2.epa.gov/hydraulicfracturing (last updated Feb. 14, 2013).

327. REBECCA HAMMER & JEANNE VANBRIESEN, NATURAL RESOURCES DEFENSE COUNCIL, IN FRACKING'S WAKE: NEW RULES ARE NEEDED TO PROTECT OUR HEALTH AND ENVIRONMENT FROM CONTAMINATED WASTEWATER (2012), *available at* http://www.nrdc.org/energy/files/Fracking-Wastewater-FullReport.pdf. The report states:

> The most common management options currently in use are recycling for additional hydraulic fracturing, treatment and discharge to surface waters, underground injection, storage in impoundments and tanks, and land application (road spreading). All of these options present some risk of harm to health or the environment, so they are regulated by the federal government and the states. But many of the current regulatory programs are not adequate to keep people and ecosystems safe.

Id. at 3.

328. Ian Urbina, *Drilling Down*, N.Y. TIMES, http://www.nytimes.com/interactive/us/DRILLING_DOWN_SERIES.html?_r=0 (last visited Mar. 6, 2013). New York Times reporter Ian Urbina explored many of these issues in a series of articles titled *Drilling Down*. *See id.*

329. Sorell E. Negro, *Fracking Wars: Federal, State and Local Conflicts over the Regulation of Natural Gas Activities*, 35 ZONING AND PLANNING LAW REPORT, 7 (2012), *available at* http://www.stcplanning.org/usr/Program_Areas/Energy/Naturalgas_Resources/Zoning%20and%20Plannin

and monitoring are needed to evaluate potential damage from fracking. State legislatures should consider adopting strict liability laws.[330] Bonds and other forms of financial assurance must be put in place before fracking begins; this is especially important given the many "wildcat" operators in the business.[331] The heavy truck traffic associated with fracking causes significant damage to local roads, which often imposes costs on surrounding communities.[332] Finally, decommissioning funds must be established and funded upfront, particularly since the rate of depletion has proven to be much faster than investors anticipated.[333]

Once all of the environmental and social costs of fracking are accounted for, it may well turn out that shale gas does not produce net economic benefits for the nation, let alone the communities that will host the hundreds of thousands of new wells needed to extract the known reserves.[334] Similar life cycle economic analyses of coal have shown that for every dollar of value created, over two dollars of economic damage is done, even without accounting for the damages from climate change.[335] But the point here is that the price of unconventional gas should reflect its full costs. Doing so will make renewables, which do not impose these kinds of externalities, look very favorable by comparison.

C. Increasing Energy Efficiency by Fifty Percent by 2025

Improving energy efficiency[336] in our homes, businesses, schools, governments, and industries—which consume more than seventy percent of the nation's natural gas and electricity—is one of the most constructive, cost-effective ways to address the challenges of high energy prices, energy security and independence, air pollution, and climate change. Energy efficiency remains critically underutilized in

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g%20Law%20Report,%20Fracking%20Wars,%20federal,%20state,%20and%20local%20conflicts%20over%20the%20regulations%20of%20natural%20gas%20activities.pdf.

330. RYAN MURPHY ET AL., BEACON HILL INSTITUTE, STRICT LIABILITY FOR FRACKING: RISKS SHOULD FALL ON WALL STREET, NOT MAIN STREET (2012), *available at* http://www.beaconhill.org/BHIStudies/Energy/Fracking2012-0924RM.pdf.

331. *See* ENV'T AM., THE COSTS OF FRACKING: THE PRICE TAG OF DIRTY DRILLING'S ENVIRONMENTAL DAMAGE 1 (2012), *available at* http://www.environmentamerica.org/sites/environment/files/reports/The%20Costs%20of%20Fracking%20vUS.pdf.

332. *Id.* at 25. Jim Efstathiou Jr., *Taxpayers Pay as Fracking Trucks Overwhelm Rural Cow Paths*, BLOOMBERG BUSINESSWEEK (May 15, 2012), http://www.businessweek.com/news/2012-05-15/taxpayers-pay-as-fracking-trucks-overwhelm-rural-cow-paths.

333. Ian Urbina, *Insiders Sound an Alarm Amid a Natural Gas Rush*, N.Y. TIMES (June 25, 2011), http://www.nytimes.com/2011/06/26/us/26gas.html?pagewanted=all; *Drill Baby Drill! The Fracking Bubble is Bursting!* DAILYKOS (Aug. 15, 2012), http://www.dailykos.com/story/2012/08/15/1119969/-Drill-Baby-Drill-The-Fracking-Bubble-is-Bursting#.

334. "There were more than 493,000 active natural-gas wells across 31 states in the U.S. in 2009, almost double the number in 1990." *Fracking*, SOURCEWATCH, http://www.sourcewatch.org/index.php/Fracking (last updated Feb. 15, 2013); EIA estimates that bringing most of the U.S. shale gas and shale oil resources into production will require more than 630,000 new wells, in addition to the approximately 487,627 natural gas wells producing in 2010. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2012, *supra* note 153.

335. Nicholas Z. Muller et al., *Environmental Accounting for Pollution in the United States Economy*, 101 AM. ECON. REV., 1649–75 (2011), *available at* http://www.aeaweb.org/articles.php?doi=10.1257/aer.101.5.1649.

336. "Energy efficiency" refers to using less energy to provide the same or an improved level of service to the energy consumer in an economically efficient way. As used here, the term includes using less energy at any time, including at times of peak demand through demand response and peak shaving efforts.

the nation's energy portfolio even though greater efficiency investments appear forthcoming. A recent study out of Lawrence Berkeley National Laboratory projected spending on efficiency to double over the next decade, potentially rising to $9.5 billion by 2025.[337]

Energy efficiency provides multiple public policy benefits regardless of its carbon emissions impacts. It reduces home and business energy costs, improves productivity, stimulates economic growth, reduces energy market prices, improves energy systems reliability, reduces criteria air pollutant emissions, and enhances national energy security.[338] Efficiency typically costs less than conventional energy supply technologies, and thus reduces the overall cost of energy services.[339] Energy consumption per dollar of United States economic output has fallen by half since the 1970s, fueling sustained economic growth and softening the economic damage from recent energy price surges.[340] Efficiency has become a quiet engine of prosperity for the United States and other economies, and is at the forefront of a new wave of clean energy investment that can support economic prosperity as well as energy security and environmental protection.

Increased energy efficiency investment combats global climate change in two primary ways. First, and most obvious, the less energy used, the fewer emissions produced. While this general statement does not fully reflect the complex relationships between energy efficiency and carbon dioxide ("CO_2") emissions, it places energy efficiency in a core role for future energy and climate policies and programs. Second, cost-effective energy efficiency achieves these environmental benefits at low cost, and thus can reduce the economic costs of achieving climate policy goals. In other words, pursuing energy efficiency wherever it costs less than other low-emission options will lower the overall costs of the policy.

The blueprint for how the nation could achieve significant energy efficiency improvements in the near term, and buy precious time to allow renewables to penetrate the market, is laid out in the National Action Plan for Energy Efficiency: Vision for 2025.[341] This plan demonstrates that there are cost-effective strategies "available . . . to meet 50 percent or more of the expected load growth" nationally, "similar to meeting 20 percent of electricity consumption and 10 percent of natural gas consumption given current forecasts for future energy demand."[342] "The benefits from achieving this magnitude of energy efficiency nationally can be estimated to be more than $100 billion in lower energy bills in 2025 than would otherwise occur, over $500 billion in net savings,"[343] and "[r]eductions in greenhouse gas

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337. Umair Irfan, *U.S. Efficiency Spending Projected to Double, Offset Most Demand Increased*, E&E RPTR. (Jan. 2013).

338. U.S. ENVTL. PROT. AGENCY, CLEAN ENERGY-ENVIRONMENT GUIDE TO ACTION: POLICIES, BEST PRACTICES, AND ACTION STEPS FOR STATES (2006), *available at* http://www.epa.gov/statelocalclimate/ documents/pdf/guide_action_full.pdf.

339. KAREN EHRHARDT-MARTINEZ & JOHN A. LAITNER, AMERICAN COUNCIL FOR AN ENERGY-EFFICIENT ECONOMY, THE SIZE OF THE U.S. ENERGY EFFICIENCY MARKET: GENERATING A MORE COMPLETE PICTURE (2008), *available at* http://aceee.org/research-report/e083.

340. *Id.* at 6–8.

341. ENVTL. PROT. AGENCY, NATIONAL ACTION PLAN FOR ENERGY EFFICIENCY VISION FOR 2025: A FRAMEWORK FOR CHANGE (2008), *available at* http://www.epa.gov/cleanenergy/documents/suca/ vision.pdf.

342. *Id.* at 2-1.

343. *Id.* at ES-2.

emissions on the order of 500 million metric tons of CO_2 annually, equivalent to 90 million cars off the road."[344]

D. Integrating Gas and Renewables as Complementary Strategies

Modern combined-cycle combustion turbine ("CCCT") gas-fired plants are not only extremely efficient and more cost effective than coal or nuclear plants, but CCCT plants can also be licensed and built within a shorter period of time and are faster at cycling and startup.[345] This makes gas an excellent base load complement to the interruptible power of renewables, which cannot always provide consistent generation, making their availability difficult to predict with great precision.[346] However, as with everything related to energy, the marriage of gas and renewables is complicated.[347] In the battle for the climate, this union "between renewables and natural gas, although not perfect, may be one of the key components to kick-start growth in climate friendly electricity generation."[348]

Another strategy is to use renewables as a hedge against the volatility of gas prices. Between 1990 and 2012, the price of natural gas has shown volatility between twenty percent and sixty percent.[349] Prices this high reduce the operating economics of existing gas plants dramatically. Among the uncertainties related to the price of natural gas are potential regulations or limits on fracking, tighter limits on methane emissions, and uncertainty around unproven reserves. Other unknowns include the ultimate size and production cost of the natural gas resource base in the United States and globally, the evolution of international gas markets, GHG control measures that will be adopted in the United States and abroad, and the broader energy technology mix, as determined by both the costs of different technologies over time and emissions policies.[350]

As noted by a recent a report from the Rocky Mountain Institute, wind provides significant hedge value for buyers of power. [351] Given the volatility of gas prices, wind can provide a hedge to protect ratepayers. Utilities may be able to convince PUCs to allow them to redirect a portion of their current hedging cash flows into wind power purchase agreements ("PPA").

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344. *Id.* at 2-1.

345. "Total installed costs of CCCTs are typically in the range of $1,100 per kW, or roughly $330 million for a 300 MW plant. Many projects are completed in 3 to 4 years, including initial project development and construction, compared to 5 to 10 years or more for coal and nuclear projects." KEITH ET AL., *supra* note 223, at 36.

346. Lothar Balling, *Fast Cycling and Rapid Start: New Generation generation of Plants Achieves Impressive Results*, MODERN POWER SYSTEMS, *reprinted in* COMBINED CYCLE, Jan. 2011, at 3, *available at* http://www.energy.siemens.com/br/pool/hq/energy-topics/technical-papers/Fast%20cycling%20and%20 rapid%20start-up.pdf.

347. Judith Romero, *Natural Gas and Renewables: A Perfect Match or Misguided Concept?*, SLS NEWS, (Jan. 21, 2011), http://blogs.law.stanford.edu/newsfeed/2011/01/21/natural-gas-and-renewables-a-perfect-match-or-misguided-concept/.

348. *Id.*

349. Since de-regulation of gas prices in 1989, "there has been a consistent trend" in gas price volatility. LISA HUBER, ROCKY MOUNTAIN INST., UTILITY-SCALE WIND AND NATURAL GAS VOLATILITY, 7 (2012), *available at* http://www.rmi.org/Knowledge-Center/Library/2012-07_WindNaturalGasVolatility.

350. *See* Romero, *supra* note 347.

351. HUBER, *supra* note 349.

The claim has been made that America has a ninety-year supply of natural gas.[352] However, such figures should be viewed with some skepticism because they are often based on estimates that include "proved" reserves, "possible" reserves, and "speculative" reserves.[353] If these figures are narrowed down to proven, technically exploitable resources based upon current natural gas consumption rates, more cautious estimates put the supply at roughly eleven to twenty-one years.[354] Under this more conservative scenario, "the United States could become a net gas importer by 2035."[355] This is yet another reason to husband the gas resources and not burn them as fast as possible.

A criticism often heard concerning renewable energy is that it is costly and unreliable; however, using natural gas to complement renewable energy sources could mitigate these factors. [356] "With cheap gas replacing coal, power system costs should decline over time . . . leaving a chunk of savings that could be applied to renewables investment with relatively low impact on consumer rates."[357] Supplementary gas-powered resources will further lower costs and account for the variability inherent to renewable energy sources.[358]

IV. CONCLUSION

In his second inaugural address, President Obama said: "We will respond to the threat of climate change, knowing that the failure to do so would betray our children and future generations."[359] While acknowledging that the "path towards sustainable energy sources will be long and sometimes difficult," the President called upon Americans to lead the transition to cleaner technologies: "That's how we will maintain our economic vitality and our national treasure—our forests and waterways, our crop lands and snow-capped peaks." Strong words that raise high expectations.

But conventional wisdom says there is no prospect for any climate legislation in the foreseeable future. Other issues—the unemployment rate, the deficit, gun control, immigration reform—will likely occupy center stage for at least the next couple of years. But there are a great number of ways the president can act that do not require the support of Congress. He can deny the permit for the Keystone XL tar sands pipeline.[360] He can appoint a strong EPA Administrator with instructions to fully enforce the requirements of the Clean Air Act starting with setting carbon

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352. *Natural Gas Supply*, NGV AMERICA, http://www.ngvc.org/naturalgas/index.html (last visited Mar. 6, 2013).

353. POTENTIAL GAS COMMITTEE, BIENNIAL REPORT 2011, CH. 21 (2011) http://potentialgas.org/biennial-report#chapter21.

354. Chris Nelder, *What the Frack?*, SLATE (Dec. 29, 2011), http://www.slate.com/articles/health_and_science/future_tense/2011/12/is_there_really_100_years_worth_of_natural_gas_beneath_the_united_states_.html.

355. *Id.*

356. Doran & Reed, *supra* note 173.

357. *Id.*

358. *Id.*

359. President Barack Obama, Inaugural Address, (Jan. 21, 2012), *available at* http://www.whitehouse.gov/ the-press-office/2013/01/21/inaugural-address-president-barack-obama.

360. According to James Hansen, opening up tar sands development means "game over for the climate." James Hansen, *Game Over for the Climate*, N.Y. TIMES (May 9, 2012), http://www.nytimes.com/2012/05/10/opinion/game-over-for-the-climate.html?_r=0.

standards for existing power plants and other major sources.[361] He can make improving energy efficiency a core mission of the federal government.[362] He can use the power of the bully pulpit and his considerable oratorical skills to mobilize public support for congressional action to avoid the climate cliff by enacting a game-changing law like a rising carbon tax. And perhaps most importantly, he should rethink the "all of the above" approach to energy policy and instead adopt a strategy of climate stabilization, national security, and economic recovery through clean energy and make renewables the centerpiece of the future energy paradigm

In 1944 General British Lieutenant-General Frederick Browning stood defeated before the last of five bridges. In a bold effort to invade Germany, the Allies needed to secure five bridges to gain passage through the Netherlands into Northern Germany. The Allies underestimated the levels of resistance and failed at the last bridge. Without the kinds of off-ramps or escape routes outlined here, natural gas may also prove to be a bridge too far to reach a safe climate.

361. *See generally* ADNIEL A. LASHOF, ET AL., NRDC REPORT: CLOSING THE POWER PLANT CARBON POLLUTION LOOPHOLE (2012), *available at* http://www.nrdc.org/air/pollution-standards/files/pollution-standards-report.pdf.

362. *See generally* FEDERAL LEADERSHIP IN ENVTL., ENERGY, AND ECON. PERFORMANCE, 74 Fed. Reg. 52117 (Oct. 8, 2009), *available at* http://wbdg.org/ccb/FED/FMEO/ eo13514.pdf.