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Phasing Out Fossil Fuels

David M. Driesen*

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I. INTRODUCTION

The problem of global climate disruption requires a rather specific solution, the phase-out of fossil fuels.[1] Most policy experts and policymakers are understandably reluctant to face up to the need for such an ambitious change.[2] So, we tend to talk about climate policy in the traditional language of environmental law, discussing the need for emission reductions.

* University Professor, Syracuse University. J.D. Yale Law School. The author would like to thank Nicholas Cortese and Joseph Frateschi for research assistance.

1. *See* Myles Allen et al., Commentary, *The Exit Strategy*, NATURE REP. CLIMATE CHANGE, May 2009, at 56, 58, http://www.nature.com/climate/2009/0905/pdf/climate.2009.38.pdf (calling for phasing out net carbon dioxide emissions altogether and leaving substantial fossil fuel resources in the ground); James Hansen et al., *Target Atmospheric CO_2: Where Should Humanity Aim?*, 2 OPEN ATMOSPHERIC SCI. J. 217, 228 (2008), http://www.benthamscience.com/open/toascj/articles/V002/217TOASCJ.pdf (concluding that "remaining fossil fuel reserves should not be exploited without a plan for retrieval and disposal of resulting atmospheric CO_2"); Veerabhadran Ramanathan & Yangyang Xu, *The Copenhagen Accord for Limiting Global Warming: Criteria, Constraints, and Available Avenues*, 107 PNAS 8055, 8057 (2010) (including the replacement of fossil fuels with renewables as things we must do in order to halve emissions by 2050 while calling for eighty percent reductions by 2100); Henry Shue, *Climate Hope: Implementing the Exit Strategy*, 13 CHI. J. INT'L L. 381, 388–89 (2013) (pointing out that many of the studies cited above may understate the need for aggressive action because they focus only on carbon dioxide, ignoring other greenhouse gases); Michael Le Page, *IPCC Digested: Just Leave the Fossil Fuels Underground*, NEW SCIENTIST (Oct. 1, 2013), http://www.newscientist.com/article/dn24299-ipcc-digested-just-leave-the-fossil-fuels-underground.html (interpreting the latest Intergovernmental Panel on Climate Change draft as a call to leave recoverable fossil fuels in the ground); Alex Morales, *Fossil Fuels Need to Stay Unburned to Meet Climate Target*, BLOOMBERG (Sept. 27, 2013, 9:48 AM), http://www.bloomberg.com/news/2013-09-27/fossil-fuels-need-to-stay-unburned-to-meet-climate-target.html.

2. *See* Ramanathan & Xu, *supra* note 1, at 8055–56; Le Page, *supra* note 1.

But ultimately, routine emission reductions will not suffice; we need the virtual elimination of emissions and that requires the phase-out of fossil fuels.[3]

This may seem like a radical claim, but we certainly will phase out fossil fuels. Because they are finite resources, they will run out eventually.[4] The question for policymakers then is not whether to phase out fossil fuels; it is whether to do so in time to avoid many of global climate disruption's impacts in a planned way, or whether to wait until after carbon dioxide emissions throw the climate radically off kilter and our limited fossil fuel resources become fiendishly expensive, perhaps suddenly, and then run out altogether. A planned and reasonably rapid fossil fuel phase-out minimizes economic and environmental disruption.[5]

Facing up to this need would hardly answer all the questions we might ask about appropriate climate disruption policy. But it might change the questions we consider worth asking in productive ways.

This paper will begin by making the case for a goal of phasing out of fossil fuels. It will then discuss the questions that adopting a phase-out goal raise about both politics and policy.

II. ON THE NEED TO PHASE OUT FOSSIL FUELS

We need to phase out fossil fuels for four major reasons. First, the predicted and possible consequences of climate disruption are too serious for us to risk continued emissions of fossil fuels until they run out.[6] Second, carbon dioxide emissions from burning fossil fuels account for some eighty percent of greenhouse gas emissions both in the United States and globally.[7] Third, carbon dioxide—once emitted—remains in the atmosphere for

3. WORKING GRP. I, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2013: THE PHYSICAL SCIENCE BASIS 26 (2013) (noting that "a large fraction of . . . climate [disruption] . . . is irreversible," and that even with *cessation* of emissions "temperature[] will remain . . . constant at elevated levels").

4. *See* Allen et al., *supra* note 1, at 57–58; Hansen et al., *supra* note 1, at 228.

5. Allen et al., *supra* note 1, at 57.

6. *See* WORKING GRP. II, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: IMPACTS, ADAPTATION AND VULNERABILITY 11–13 (2007) [hereinafter WORKING GRP. II, CLIMATE CHANGE 2007] (discussing impacts in detail); WORKING GRP. II, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2001: IMPACTS, ADAPTATION AND VULNERABILITY 5, 77 (2001) [hereinafter WORKING GRP. II, CLIMATE CHANGE 2001].

7. ENVTL. PROT. AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2011 ES-9 (2013).

centuries, so that emissions have a cumulative effect.[8] This means that every year in which we burn any fossil fuels we will add to climate disruption, even if we have reduced emissions by a large amount.[9] Fourth, fossil fuels cause an enormous amount of destruction wholly apart from climate disruption.[10]

Serious scientists do not doubt that greenhouse gas emissions have disrupted the climate and will wreak greater havoc still in the future absent drastic changes.[11] The average mean surface temperature has risen in response to rising greenhouse gas emissions.[12] We have a rather good understanding of the sorts of disruption rising temperatures create.[13] This conference devoted a lot of attention to one of the most basic consequences of all—sea level rise—which has dire implications for Florida.[14] Other consequences we can expect include more violent weather events, increasing drought, the spread of infectious diseases, the loss of many endangered species, and the destruction of ecosystems.[15] As with sea level rise, our understanding of the magnitude and timing of these consequences is quite limited.[16] We have generally underestimated the extent of global warming in the past and some ice masses have melted much more quickly than

8. *See* WORKING GRP. I, *supra* note 3, at 26 (pointing out that carbon dioxide emissions generate climate change that is mostly "irreversible on a multi-century to millennial time scale").

9. *See id.*; Allen et al., *supra* note 1, at 58.

10. *See* David M. Driesen, *Sustainable Development and Air Quality: The Need to Replace Basic Technologies with Cleaner Alternatives*, 10 BUFF. ENVTL. L.J. 25, 35–37 (2002) [hereinafter Driesen, *Sustainable Development and Air Quality*] (describing harms associated with fossil fuel burning).

11. *See* WORKING GRP. I, *supra* note 3, at 2–17 (discussing warming trends, their attribution to greenhouse gas emissions, and likelihood of further warming).

12. *See id.* at 2, 11–13, 15.

13. *See id.* at 17–27.

14. *See* WORKING GRP. II, CLIMATE CHANGE 2001, *supra* note 6, at 5 (discussing flooding from sea level rise).

15. WORKING GRP. II, CLIMATE CHANGE 2007, *supra* note 6, at 12, 792 (discussing "increased deaths, disease and injury due to heatwaves [sic], floods, storms, fires, and droughts" and expressing high confidence about loss of endangered species and ecosystem destruction); WORKING GRP. II, CLIMATE CHANGE 2001, *supra* note 6, at 5, 42–43 (discussing increased incidence of diseases such as malaria, cholera, dengue, and heat stroke mortality).

16. *See, e.g.*, FRANK ACKERMAN & ELIZABETH A. STANTON, CLIMATE ECONOMICS: THE STATE OF THE ART 11–15 (2013) (discussing uncertainties about sea level rise and other key variables).

expected.[17] Intergovernmental Panel on Climate Change reports generally admonish readers to expect surprises, some of which may prove unpleasant.[18] The climate system includes feedback loops that have the potential to greatly accelerate climate disruption.[19] For example, a lot of methane lies trapped below permafrost in Siberia and elsewhere.[20] As the earth warms, it has melted some of this permafrost, allowing some of the methane trapped beneath to escape.[21] Methane itself is a very potent greenhouse gas, so the released methane increases warming, which can melt yet more permafrost and lead to the release of more methane.[22] In other words, runaway global warming is a possibility, where consequences of our previous actions set up a cycle of warming that we cannot prevent through emission reductions.[23] The possibility of calamitous warming exceeding the amount predicted by most models cannot be ruled out, partially because of these sorts of feedback loops.[24] We do not know where a tipping point lies, which once crossed, could have very dire consequences.[25] Because of the serious consequences predicted and the scary nature of what could happen but cannot be predicted, we need to do everything we can to avoid future temperature increases.

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17. *See id.* at 12 (explaining that temperature increases have followed the most pessimistic projections and that sea level rise has outstripped the main projections altogether).

18. WORKING GRP. II, CLIMATE CHANGE 2007, *supra* note 6, at 497 (stating that "surprises should be anticipated" and are of great concern); WORKING GRP. II, INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 1995: IMPACTS, ADAPTATIONS AND MITIGATION OF CLIMATE CHANGE: SCIENTIFIC-TECHNICAL ANALYSES 5 (1996) (characterizing surprises as *likely*).

19. ACKERMAN & STANTON, CLIMATE ECONOMICS, *supra* note 16, at 15–18 (describing various feedbacks).

20. *See id.* at 17–18 (describing methane in the boreal region and elsewhere).

21. *Arctic Melt "Bubbling Out" Ancient Methane*, ASIAN NEWS INT'L, May 21, 2012 (stating, "[s]cientists have [discovered] thousands of sites in the Arctic where [trapped] methane . . . is seeping out" from melting permafrost); Steve Connor, *Vast Methane 'Plumes' Seen in Arctic Ocean as Sea Ice Retreats*, INDEP. (Dec. 13, 2011), http://independent.co.uk/news/science/vast-methane-plumes-seen-in-arctic-ocean-as-sea-ice-retreats-6276278.html (describing scientists' shock after witnessing *plumes of methane* being released from permafrost and the Arctic seabed).

22. *See* ACKERMAN & STANTON, CLIMATE ECONOMICS, *supra* note 16, at 17–18 (discussing the warming from released methane).

23. *See* WORKING GRP. II, CLIMATE CHANGE 2007, *supra* note 6, at 249 (characterizing feedbacks from permafrost melting as *key uncertainties* in need of further research).

24. *See* Elmar Kriegler et al., *Imprecise Probability Assessment of Tipping Points in the Climate System*, 106 PNAS 5041, 5041 (2009).

25. *See id.* (discussing tipping points and our inability to accurately gauge the probability of triggering them).

Because roughly eighty percent of the United States greenhouse gas emissions come from burning fossil fuels, any serious effort to address climate disruption must have the project of addressing fossil fuel burning as its centerpiece.[26] This does not mean that addressing fossil fuel use constitutes the only thing we need to do to address global climate disruption, but it does mean that successfully addressing fossil fuel use must take center stage. That is why this symposium, like other serious efforts to address climate disruption, focuses so heavily on energy policy questions.[27]

Even if we reduce emissions, we will make climate disruption worse every year in which we continue to burn any fossil fuel at all.[28] Carbon dioxide, once emitted, remains in the atmosphere for many centuries.[29] Given the nature of the consequences and the possibility of triggering runaway warming, we just cannot continue to increase the global store of atmospheric carbon year after year until fossil fuels run out. Continued emissions commit us to future disruption of unknown magnitude.[30] If we find out later that we have crossed some sort of threshold or triggered routine consequences that we cannot easily live with, such as a level of sea level rise that inundates Miami, we cannot reverse these consequences by subsequently reducing emissions.[31] This means, as Howard A. Latin has emphasized, that reducing emissions by ten percent—for example—increases warming above current levels.[32] For a ten percent reduction implies that we continue to add

26. *See* ENVTL. PROT. AGENCY, INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990–2011 ES-9 (2013) (showing that carbon dioxide made up seventy-nine percent of United States greenhouse gas emissions in 2011); *cf.* INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2007: SYNTHESIS REPORT 36 fig.2.1 (2008) (indicating that fossil fuels account for 56.6% of global greenhouse gas emissions).

27. *See, e.g.*, Robert S. Pindyck, *Climate Change Policy: What Do the Models Tell Us?*, 51 J. ECON. LITERATURE 860, 860 (2013).

28. *See* Driesen, *Sustainable Development and Air Quality*, *supra* note 10, at 35.

29. *See* Ramanathan & Xu, *supra* note 1, at 8056 (pointing out that the residence time for carbon dioxide is up to one thousand years).

30. *See* Driesen, *Sustainable Development and Air Quality*, *supra* note 10, at 35–36.

31. WORKING GRP. I, *supra* note 3, at 26 (noting that even after complete cessation of emissions, elevated temperatures will remain constant for centuries).

32. HOWARD A. LATIN, CLIMATE CHANGE POLICY FAILURES: WHY CONVENTIONAL MITIGATION APPROACHES CANNOT SUCCEED 20–21 (2012) (pointing out that a ten percent cut in emissions implies continued additions to greenhouse gas concentrations in the atmosphere).

ninety percent of current emissions to the global store of carbon every year, thus adding to the current imbalance in the global carbon cycle.[33]

Reducing carbon dioxide emissions to zero or near zero levels requires a fossil fuel phase-out.[34] Because of the cumulative nature of the emissions, the importance of carbon dioxide to the overall problem, and the seriousness of the potential consequences of increasing climate disruption, we must phase out fossil fuels long before they run out. The sooner the fossil fuels are phased out, the smaller the likelihood of triggering runaway warming or suffering some of the more serious consequences associated with warming generally.[35]

Although I have discussed a phase-out as the right response to global climate disruption, a goal of phasing out fossil fuels has broader merit. Burning fossil fuels contributes greatly to severe local and regional air pollution problems that kill tens of thousands of people annually in the United States and even more in developing countries.[36] Phasing out fossil fuels promises relief from serious conventional air pollution, coal mining's destruction of land and maiming or killing of miners, an end to oil spills, and much more.[37] The harms avoided when we phase out fossil fuels go far beyond limiting climate disruption.

III. HOW TO PHASE OUT FOSSIL FUELS

Phasing out fossil fuels would require a number of changes.[38] The most obvious reform needed involves greatly increased energy efficiency.[39]

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33. *Id.* at 21 (equating a ten percent cut in emissions with the addition of ninety percent of baseline emissions to the atmosphere).

34. Shue, *supra* note 1, at 386, 394.

35. *See* Bill McKibben, *Global Warming's Terrifying New Math*, ROLLING STONE, Aug. 2, 2012, *available at* http://www.rollingstone.com/politics/news/global-warmings-terrifying-new-math-20120719 (explaining that avoiding an increase in mean surface temperature of two degrees Celsius, which scientists consider dangerous, would require leaving eighty percent of current proven industry owned fossil fuel reserves in the ground).

36. Driesen, *Sustainable Development and Air Quality*, *supra* note 10, at 28, 35 (pointing out that health studies link particulate pollution to tens of thousands of annual deaths); *e.g.*, Edward Wong, *Early Deaths Linked to China's Air Pollution Totaled 1.2 Million in 2010, Data Shows*, N.Y. TIMES, Apr. 2, 2013, at A9.

37. *See, e.g.*, Driesen, *Sustainable Development and Air Quality*, *supra* note 10, at 51–52.

38. *Id.* at 25.

39. *See* John C. Dernbach et al., *Energy Efficiency and Conservation: New Legal Tools and Opportunities*, NAT. RESOURCES & ENV'T, Spring 2011, at 7, 7 (characterizing energy efficiency as *low-hanging fruit*).

Increases in energy efficiency reduce the scope of the project of replacing fossil fuel as the basis for our economy.[40] Happily, many energy efficiency improvements pay for themselves through savings in electricity costs.[41] They also produce jobs for contractors and engineers.[42] So, they produce win-win situations that prove attractive to rational policymakers.

Fuel switching to achieve zero emissions, even for a greatly reduced energy requirement, however, poses significant challenges.[43] In 2012, renewable energy and nuclear power accounted for less than twenty percent of United States energy consumption.[44] About eighty percent came from fossil fuels.[45] At current levels of total energy consumption, we must replace almost eighty quads of fossil fuel energy in order to reach zero emissions.[46] Even a fifty percent energy efficiency improvement—an ambitious level—would leave us with the need to replace almost forty quads of energy, a significant amount.[47] If a phase-out is possible, it would likely require ambitious policy measures, and might produce significant costs.

Thoroughly analyzing the question of whether a *complete* phase-out is possible would require an article of its own. I will note that a recently published analysis suggests that my home state, New York, could replace all of its fossil fuel with renewable energy.[48] It does not necessarily follow that all areas in the country could rely solely on renewables, as renewables' potential varies geographically.[49] The optimistic picture for New York depends heavily on offshore wind possibilities that take advantage of New York's proximity to Long Island Sound and some of the Great Lakes.[50] But if a nationwide shift to one hundred percent renewables is not possible, then phasing out fossil fuels might require some use of nuclear power.

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40. *See id.*

41. *Id.* (discussing studies finding *substantial* opportunities to save money through energy efficiency improvements are available).

42. *See id.* (finding that energy efficiency improvements generate jobs).

43. *See* Mark Z. Jacobson et al., *Examining the Feasibility of Converting New York State's All-Purpose Energy Infrastructure to One Using Wind, Water, and Sunlight*, 57 ENERGY POL'Y 585, 586–87 (2013).

44. *See* U.S. ENERGY INFO. ADMIN., MONTHLY ENERGY REVIEW 3 tbl.1.1 (2014), *available at* http://www.eia.gov/totalenergy/data/monthly/archive/00351401.pdf.

45. *Id.*

46. *See id.* (showing 77.994 quads of fossil fuel related energy consumption in 2012).

47. *See id.*

48. Jacobson et al., *supra* note 43, at 598.

49. *See id.* at 598–99.

50. *See id.* at 589 tbl.2 (showing that the study relies on off-shore wind for forty percent of its power in 2030).

The history of serious efforts to make major changes should make us somewhat optimistic about a phase-out's prospects. When we moved toward phasing out ozone depleting substances, we discovered that more substitutes existed at lower costs than academic researchers or experts at individual companies had believed.[51] Although a fossil fuel phase-out appears to pose much greater challenges than the phase-out of ozone depleting chemicals, aggressive policies have already produced surprising results and probably will produce more of them.[52] The ozone depletion experience teaches us that we should be wary of claims that we know how rapidly we can phase out fossil fuels and how much it will cost. For many years prior to the initiation of the phase-out of ozone depleting chemicals, it appeared that substitutes would either be impossible or costly.[53] This proved not to be the case.[54] I am not saying that we can confidently predict that phasing out fossil fuels will prove cheap. But we must recognize that academic studies lack information individual companies may possess on technological possibilities, that individual companies may have incentives not to share information they have, and that new research can uncover possibilities that nobody knew about.[55] Strong policies have generally done well at encouraging innovation.[56]

IV. SOME TECHNOCRATIC QUESTIONS

Even if we agree that we should phase out fossil fuels, important questions remain about how quickly we should do so and what policy

51. *See* EDWARD A. PARSON, PROTECTING THE OZONE LAYER: SCIENCE AND STRATEGY 9 (2003) (stating that "it was widely believed that significant cuts in ozone-depleting chemicals would be extremely difficult and costly," but that agreement to a fifty percent cut created collaborations that led to subsequent identification and development of alternatives).

52. *See, e.g.*, Daniel T. Kaffine et al., *Emissions Savings from Wind Power Generation in Texas*, ENERGY J., 2013, at 155, 156 (discussing technological advances and falling prices of wind energy).

53. PARSON, *supra* note 51, at 8–9 (pointing out that ten years of deadlock preceded the Montreal Protocol and that during that period many believed that cuts would be costly and difficult).

54. *See id.* at 9.

55. *See, e.g.*, *id.* (arguing that prior to regime formation, knowledge about substitutes for ozone depleters was controlled by firms, not academics, and not shared).

56. *See* David M. Driesen, *Does Emissions Trading Encourage Innovation?*, 33 ENVTL. L. REP. 10094, 10103–04, 10106 (2003) [hereinafter Driesen, *Does Emissions Trading Encourage Innovation?*] (reviewing empirical evidence of innovation and finding it correlated with stringent standards).

mechanisms we should use to accomplish this. I address both of these issues in turn.

A. *The Speed of a Phase-Out*

The argument above suggests that we should phase out fossil fuels as quickly as feasible.[57] But what does that mean for policy? How should a policymaker determine how quickly we should phase out fossil fuels?

One might think of this rapidity question as a question about the technical feasibility of replacing fossil fuels. Although engineers studying these sorts of questions no doubt make a contribution to resolving fossil fuel policy questions, there are reasons to doubt that these questions are the most central ones for policymakers.[58] No society in the world has done all that is technically feasible to phase out fossil fuels.[59] Furthermore, what I already said about the limits of any one actor's information gathering capacity and our ability to predict advances implies that experts can easily underestimate our society's technical capabilities.

One might think that a decision to phase out fossil fuels does away with the need to consider costs. My justification for the phase-out commitment suggests a rejection of the reigning economic orthodoxy on how to consider costs—the theory that we should do so by setting emission reduction targets or prices designed to equalize costs and benefits at the margin. We should not do so for at least two reasons. First, we cannot quantify the costs and benefits of any given mitigation measure with a reasonable degree of precision, so cost-benefit analysis ("CBA") does not provide a useful guide to policy.[60] Second, a cost-benefit criterion in the

57. *See* Brigitte Knopf et al., *Managing the Low-Carbon Transition—From Model Results to Policies*, ENERGY J., 2010, at 223, 225 (arguing that the needed steep decreases in carbon intensity require rapid energy system changes).

58. *See id.* at 226; McKibben, *supra* note 35.

59. *See* Knopf et al., *supra* note 57, at 226; McKibben, *supra* note 35.

60. *See* Donald A. Brown, *Climate Change*, *in* STUMBLING TOWARD SUSTAINABILITY 273, 306–07 (John C. Dernbach ed., 2002) (discussing problems in monetizing climate disruption impacts); Frank Ackerman & Elizabeth A. Stanton, *Climate Risks and Carbon Prices: Revising the Social Cost of Carbon*, ECON. E.-J., Apr. 4, 2012, at 1, 2, http://dx.doi.org/10.5018/economics-ejournal.ja.2012-10 (explaining that plausible assumptions about climate sensitivity can generate estimates of carbon's social costs at nine hundred dollars a ton, but that many estimates have come up with much lower numbers); Jonathan S. Masur & Eric A. Posner, *Climate Regulation and the Limits of Cost-Benefit Analysis*, 99 CALIF. L. REV. 1557, 1577, 1596–97 (2011); Pindyck, *supra* note 27, at 861 (finding integrated assessment models at the base of climate disruption CBA close to useless as policy analysis tools); Wendy Wagner et al., *Misunderstanding Models in Environmental*

climate context proves even more morally obtuse for United States climate policy than in other contexts because decisions we make about climate disruption influence the amount of death, injury, and destruction faced not only in Florida, but also in Bangladesh, Sub-Saharan Africa, and in Island States.[61] It is not morally acceptable to say that we will not prevent deaths in developing countries that we—together with other developed countries—have caused, because the prevention would cost too much.[62] Nevertheless, cost constraints remain relevant to the question of how rapidly we can feasibly phase out fossil fuels.

A commitment to phasing out fossil fuels, however, changes the questions we should ask about costs. We should focus primarily on cost distribution, rather than magnitude. We should ask, for example, whether phasing out fossil fuels at a given rate would cause unacceptable hardships for energy consumers. For example, we must go slowly enough so that we do not leave people with bills so high that they cannot afford electricity, heat, and transportation. This leaves the question of how rapidly to phase out fossil fuels somewhat dependent on other policies. We can, for example, proceed more rapidly if we have good mass transit and robust programs to pay electricity bills for poor people in place.[63] Of course, that means that we also have to answer questions about how much we want to spend to enhance these sorts of programs. Furthermore, an emphasis on distribution suggests that even for relatively cheap changes we must consider the plight of workers losing their jobs as fossil fuel facilities shut down. It may be true that phasing out fossil fuels will create more jobs than it takes away.[64] In a reasonably robust economy, it may be appropriate to expect flexible labor markets to handle the necessary transitions reasonably well. If we need to accelerate fossil fuel phase-outs during periods of high unemployment, however, it may be important to have job training and other kinds of transition assistance in place to help those losing jobs in the fossil fuel industry.[65] Congress did this with respect to the acid rain program by

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and Public Health Regulation, 18 N.Y.U. ENVTL. L.J. 293, 318–19 (2010) (explaining that models illuminate dynamics and uncertainties rather than generate answers).

61. *See* Masur & Posner, *supra* note 60, at 1563.

62. *See* Brown, *supra* note 60, at 304–06 (arguing that CBA is dubious because even high costs do not free us of our responsibilities to prevent harms to others).

63. *See* Dernbach et al., *supra* note 39, at 7; Jacobson et al., *supra* note 43, at 595–96; Shue, *supra* note 1, at 384–86.

64. Jacobson et al., *supra* note 43, at 594–95; *see also* Dernbach et al., *supra* note 39, at 7.

65. *See* Clean Air Act Amendments of 1990, Pub. L. No. 101–549, § 1101, 104 Stat. 2399, 2710–11 (1990), repealed by Workforce Investment Act of 1998, Pub. L. No. 105–220, § 199, 122 Stat. 936 (1998); *cf.* Jacobson et al., *supra* note 43, at 594–95.

granting the industry flexibility in how to reduce sulfur dioxide emissions; Congress allowed the use of low sulfur coal, which would displace coal-mining jobs in high sulfur coal regions.[66] Accordingly, it did provide some transitional assistance.[67] Even though we should provide transitional assistance if we transform the economy during tough times, we should not accept using unfounded allegations of hardship to justify slowing progress.

B. *Policy Mechanisms*

Policymakers must also ask themselves about what policies can most readily phase out fossil fuels. There seems to be a political consensus around the globe that we should "put a price on carbon" through environmental benefit trading or carbon taxes.[68] Yet, if one looks around the world at advanced countries that have gone far down the road toward phasing out fossil fuels, these two policies do not always figure as causal factors.[69] Germany now produces twenty-five percent of its energy from renewable resources.[70] Its policies have produced big declines in the price of solar and other renewable energy sources.[71] As Michael Mehling has made clear, Germany has achieved this progress primarily through an aggressive feed-in tariff, which offers renewable energy producers a high price for renewable energy.[72] This policy does not directly put a price on carbon; it aims instead

66. *See* ENVTL. PROT. AGENCY, IMPACTS OF THE ACID RAIN PROGRAM ON COAL INDUSTRY EMPLOYMENT i–ii, app. at A2–A3 (2001).

67. Clean Air Act Amendments of 1990 § 1101 (allocating up to $250,000,000 for retraining and assisting miners adversely affected by employers' Clean Air Act compliance).

68. *See* WILLIAM D. NORDHAUS, ECONOMIC ISSUES IN DESIGNING A GLOBAL AGREEMENT ON GLOBAL WARMING 3 (2009), *available at* http:/ /www.econ.yale.edu/ ~nordhaus/homepage/documents/Copenhagen_052909.pdf (describing the lesson that all people must "face a market price for the use of carbon" as the economists' "bottom line for policy").

69. *See* Marc Ringel, *Fostering the Use of Renewable Energies in the European Union: The Race Between Feed-in Tariffs and Green Certificates*, 31 RENEWABLE ENERGY 1, 8–9 (2006).

70. Chris Cottrell, *German Renewables Output Hits Record High in H1*, REUTERS (July 26, 2012, 9:49 AM), http://www.reuters.com/article/2012/07/26/germany-renewables-idUSL6E8IQIA720120726.

71. Craig A. Hart & Dominic Marcellino, *Subsidies or Free Markets to Promote Renewables?*, 3 RENEWABLE ENERGY L. & POL'Y REV. 196, 203 (2012).

72. Ralph Buehler et al., *How Germany Became Europe's Green Leader: A Look at Four Decades of Sustainable Policymaking*, SOLUTIONS, Oct. 2011, at 51, 57–58; *see* Samantha Booth, *Community Solar: Reviving California's Commitment to a Bright Energy Future*, 43 ENVTL. L. REP. 10585, 10590–91 (2013) (noting that Germany has become the first country to exceed thirty gigawatts of solar capacity because of its feed-in tariff); Ringel, *supra*

to provide an incentive to substitute renewable energy for fossil fuels.[73] France currently relies on fossil fuels for less than ten percent of its energy.[74] This extraordinary achievement stems from a government decision to build nuclear power plants with rigid state control of both design and worker training in order to ensure safety.[75] France did not put a price on carbon; instead, it mandated construction of zero emission facilities.[76] This record should invite some fairly simple questions: Can putting a price on carbon be an effective strategy for phasing out fossil fuels? If so, what sorts of design features are needed to make this approach more effective than in the past? Are there better tools than taxes and trading for phasing out fossil fuels? What are the advantages and limits of pricing carbon as a strategy?

I do not propose to answer all of these questions here, but I will say something about possible answers. First of all, pricing policies must be much more ambitious than the pricing policies countries have employed so far if they are to have any chance in succeeding in rapidly phasing out fossil fuels.[77] Countries have generally set caps for trading programs and carbon taxes without any clear intention to phase out fossil fuels.[78] Indeed, in Europe, which has the most experience with these programs, the primary goal of many of these policies is to reduce emissions rather modestly in the near term.[79] Howard Latin has questioned this sort of back-loaded strategy that saves ambitious reductions for much later.[80] He has raised concerns that such strategies encourage investments in technologies, such as natural gas, that we must ultimately abandon to get to zero emissions and that those who make these investments will resist scuttling the infrastructure they have

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note 69, at 6 (explaining that a feed-in tariff pays renewable energy providers an above market price for the power they produce).

73. Ringel, *supra* note 69, at 6.

74. NUCLEAR ENERGY AGENCY, ORG. FOR ECON. CO-OPERATION, NUCLEAR ENERGY DATA 43 (2013) (showing that France gets only 9.8% from fossil fuels).

75. *See id.* (showing that France gets seventy-five percent of its power production from nuclear energy); Dieter Helm, *Nuclear Power, Climate Change, and Energy Policy*, *in* THE ECONOMICS AND POLITICS OF CLIMATE CHANGE 247, 249 (Dieter Helm & Cameron Hepburn eds., 2009) (discussing France's ownership of the entire technology chain for nuclear energy and state training of the nuclear workforce).

76. *See* Helm, *supra* note 75, at 249.

77. *See, e.g.*, Ringel, *supra* note 69, at 6.

78. *See* LATIN, *supra* note 32, at 151.

79. Hart & Marcellino, *supra* note 71, at 197.

80. *See id.* at 152–53, 158 (noting that "conversion from coal to natural gas" is an interim investment that might make eventual achievement of zero emissions *more difficult*).

invested in when the time comes.[81] He would rather see us move more directly to zero emissions.[82] Adopting a goal of phasing out fossil fuels, not simply reducing emissions, does suggest that the goals for these programs have not been commensurate with the climate disruption problem.[83]

Amy Sinden and I have suggested elsewhere that a goal of phasing out fossil fuels suggests a redesign of environmental benefit trading programs.[84] Current approaches focus on the end-of-the-pipe and are designed to reduce emissions.[85] We argued for explicitly using trading to phase out fossil fuels.[86] This implies that allowances would limit the amount of fossil fuels being used in the economy.[87] We refer to trading—and non-trading—programs that limit dirty inputs rather than pollution outputs as Dirty Input Limits ("DILs").[88] We have used DILs in both tradable and non-tradable forms before when we phased out ozone-depleting chemicals and lead.[89] This may seem like a radical idea, but proposed federal comprehensive climate disruption legislation included DILs for transportation fuels.[90] We simply suggested extending this approach.[91]

But a bigger question we must ask is whether pricing policies—which are conceived of as encouraging the most cost effective adjustments in the status quo—are really the best way of transforming an economy, even if they were ambitious. The French and German experiences suggest that some sort of more active state role might be necessary to encourage investments that are effective, and perhaps even cost effective in the long run, but not

81. *See id.* at 158 (arguing that investments in interim technologies like natural gas will build constituencies for those technologies that will make their abandonment difficult); *see also* Jacobson et al., *supra* note 43, at 587 (doubting that natural gas may produce more global warming than coal because of methane emissions associated with gas extraction and lower sulfur dioxide emissions, which mask warming).

82. *See* LATIN, *supra* note 32, at 151.

83. *See id.*

84. *See* David M. Driesen & Amy Sinden, *The Missing Instrument: Dirty Input Limits*, 33 HARV. ENVTL. L. REV. 65, 66–67, 104–09 (2009) (discussing a trading program limiting consumption of fossil fuel through tradable permits limiting fossil fuel production).

85. *See id.* at 67–68 (stating that we have traditionally focused vehicle regulation on the exhaust output).

86. *See id.* at 104–09.

87. *See id.*

88. *See id.* at 67 (defining Dirty Input Limits ("DILs")).

89. *See* Driesen & Sinden, *supra* note 84, at 83–88 (discussing the lead and ozone-depleting chemical examples).

90. *See id.* at 81–83 (discussing the use of DILs in global warming bills considered in Congress).

91. *See id.* at 67.

cost effective in the short run.[92] We need more thinking about what lessons the most successful approaches have to teach the rest of us, instead of blithe assumptions that since pricing carbon has good efficiency properties, it must be the right solution to the climate disruption problem. Indeed, it seems fairly clear that price alone will not accomplish all that is needed.[93] Mass transit improvements, for example, require public expenditures—although one can imagine using a carbon tax or auctioned permits to fund this.[94]

We also must recognize that an enormous project like phasing out fossil fuels may require a level of innovation that challenges conventional approaches, like traditional regulation, environmental taxation, and emissions trading.[95] All of these programs require governments to make difficult decisions about goals, in the form of choosing a cap for a trading program or a tax rate for a carbon tax.[96] Political difficulties and the government's inability to predict innovation rates will tend to constrain the ambition of these goal-setting decisions.[97] This raises the question of whether we can invent new approaches that will do better.

I have suggested the possibility of an environmental competition statute.[98] Such a statute would allow any polluter who is reducing carbon emissions to collect the cost of making its reductions from any competitor with higher emissions, plus a statutory profit margin.[99] In all likelihood this would spur a race to phase out fossil fuels, since getting to zero emissions generally secures payments, whereas continuing to pollute risks having to pay cleaner competitors.[100] This approach seeks to emulate the innovation stimulating properties of a very competitive market, where making a superior product allows an innovator to steal market share from its competitors,

92. *See, e.g.*, MIKAEL SKOU ANDERSEN, GOVERNANCE BY GREEN TAXES: MAKING POLLUTION PREVENTION PAY 117 (1994), *and* Buehler et al., *supra* note 72, at 57.

93. *See* Buehler et al., *supra* note 72, at 52, 57.

94. *See* Dernbach et al., *supra* note 39, at 7.

95. *See* David M. Driesen, *An Environmental Competition Statute*, 2 SAN DIEGO J. CLIMATE & ENERGY L. 199, 201–05 (2010) [hereinafter Driesen, *An Environmental Competition Statute*].

96. *Id.* at 203–04.

97. *Id.* at 203.

98. *Id.* at 200–01 (describing and advocating this mechanism).

99. *Id.* at 206–07 (describing the basic mechanism of an environmental competition statute).

100. *See* Driesen, *An Environmental Competition Statute*, *supra* note 95, at 200–01 (characterizing an environmental competition statute as "encourag[ing] contests to improve environmental quality").

thereby potentially making the innovator wealthier at the expense of less nimble competition.[101]

Howard Latin has proposed using carbon taxes to fund an expert commission to fund research into zero emissions technologies and to subsidize their deployment.[102] His approach mirrors my own in following the principle that using negative economic incentives to fund positive economic incentives provides a powerful driver for innovation.[103]

These comments focus on the most challenging aspect of the phase-out problem—the problem of fuel switching. The question of how best to minimize the use of fuel altogether—the energy efficiency problem—also raises questions about effective policies. Policymakers around the world have adopted a lot of successful approaches, from improved mass transit to least cost planning for electric utilities, to regulations mandating increased energy efficiency in appliances.[104] They have done so because of strong evidence that people often do not adopt energy efficiency measures on their own, even when doing so would save them money.[105] The data suggest that pricing policies without redistribution of the revenue may have limits in encouraging the cheapest options for limiting the use of fossil fuels. On the other hand, pricing policies that help fund energy efficiency improvements can pair economic benefits with fuel switching, thus lessening—and perhaps eliminating—the pain associated with rapid change.[106]

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101. *Id.* at 207 (developing the analogy between this statutory mechanism and the "economic dynamics of [a] competitive market[]").

102. LATIN, *supra* note 32, at 162–63 (describing this scheme along with other less central remedies).

103. ANDERSEN, *supra* note 92, at 18–19, 26–27 (promoting taxes like the French effluent tax which raise funding for environmental programs).

104. *See* Veronika Czakó, *Climate Change and Sustainable Energy Action at the City Level: The Hungarian Experience*, *in* OPPORTUNITIES AND DRIVERS ON THE WAY TO A LOW CARBON SOCIETY: PROCEEDINGS OF THE SUMMER ACADEMY 'ENERGY AND THE ENVIRONMENT' 95, 99–101 (2013) (discussing subsidies funding energy efficiency improvements in Hungarian apartment buildings); Dernbach et al., *supra* note 39, at 7 (describing various approaches used in the United States).

105. *See* Cameron Hepburn & Nicholas Stern, *The Global Deal on Climate Change*, *in* THE ECONOMICS AND POLITICS OF CLIMATE CHANGE 36, 49 (Dieter Helm & Cameron Hepburn eds., 2009) (stating that because of energy efficiency investment's insensitivity to price, carbon pricing will do little to increase deployment of energy efficiency); *cf.* Robert N. Stavins, *Addressing Climate Change with a Comprehensive US Cap-and-Trade System*, *in* THE ECONOMICS AND POLITICS OF CLIMATE CHANGE 197, 198 (Dieter Helm & Cameron Hepburn eds., 2009) (stating flatly that polluters will undertake all reductions that are less costly than the allowance price in "[a] well-designed cap-and-trade system").

106. *See id.*

V. SOME POLITICAL QUESTIONS

The major reason that the United States has not become a leader in moving toward a phase-out of fossil fuels has been political.[107] The United States has been unwilling to even take the relatively modest step of implementing a nationwide so-called cap-and-trade program to reduce greenhouse gas emissions.[108] Nor has the United States eliminated massive subsidies for fossil fuels, in spite of repeated proposals from the Obama Administration to do so.[109]

So, a major question that the need to phase out fossil fuels raises is a political one: What sorts of strategies would help change the political climate over time to one that might accept measures that would phase out fossil fuels? My own view is that we are unlikely to gain acceptance of a program phasing out fossil fuels without environmental leaders making such a phase-out an explicit political goal. The evidence suggests that the Obama Administration and many environmental groups disagree with me on that. They either do not see the need for a phase-out, or assume that it can best be accomplished by selling steps in that direction indirectly, justifying individual regulations as cost effective and helping with the problem of climate disruption.[110] Thus, the Obama Administration has passed very strong standards improving vehicle emissions and promises significant regulation of power plants, but supports an "all-of-the-above" energy strategy.[111]

I have my doubts about whether the American public can be brought around to support a phase-out of fossil fuels without a rhetorical strategy that prepares them to accept much more significant changes than are currently politically feasible. If nobody tells the American public that fossil fuels are finite resources, that an increase in their price is inevitable as they become scarce, that renewable energy has fallen in price in countries with good policies and will likely fall further if supported appropriately, that new

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107. *See* Neela Banerjee, *Warning on Greenhouse Gases; A Study Says Emissions Are on Track to Raise Global Temperatures by up to 9.54 Degrees by Century's End*, L.A. TIMES, June 11, 2013, at A11.

108. *See* Stavins, *supra* note 105, at 198; Banerjee, *supra* note 108.

109. *See* Banerjee, *supra* note 107 (stating "Congress has shown no interest in ending fossil fuel subsidies"); Gary Gentile et al., *Obama Seeks to Slash Oil Industry Tax Breaks*, PLATTS OILGRAM NEWS, Feb. 15, 2011, at 1, *available at* 2011 WLNR 5108712 (stating that, as of 2011, President Obama proposed eliminating fossil fuel subsidies three times).

110. *See, e.g.*, John M. Broder, *Limits Set on Pollution from Autos*, N.Y. TIMES, Apr. 2, 2010, at B1.

111. *See* McKibben, *supra* note 35.

industries can generate new jobs, that climate disruption will wreak havoc unless we take ambitious measures, and that phasing out fossil fuels would save thousands of lives and spare us all from many types of environmental destructions wholly apart from climate disruption, I do not see how we can ever phase out fossil fuels.

The political challenge, however, goes beyond how we debate environmental policy. We live in an era in which many politicians oppose any governmental role in solving most societal problems. Although we surely need limits on governmental power, climate disruption poses problems of coordination that make it insolvable without a significant governmental role.[112] Countries that have made significant progress on the climate issue take a more pragmatic and less ideological view of the appropriate role of government than we do. So, progress on the climate issue is linked to making progress on broader issues of the appropriate role of government.

This requires environmental advocates and their political allies in Congress to figure out how to advance a broader project of sensible governance. They should, for example, repeatedly remind the American people of the role deregulation played in creating the financial crisis.[113] Reasonable standards of conduct are as important to well-functioning markets as they are to our efforts to solve environmental problems. Furthermore, politicians who do not want to see the government dismantled need to simply say, repeatedly, that they support an adequate government. This would start a healthy debate about what constitutes an adequate government and marginalize those who oppose an adequate government. At any rate, progress in phasing out fossil fuels will require political changes and strategic actions to make them come about.[114]

I do not think it is possible for anybody to prove a view about what political strategy is best. I provide my views merely to clarify the questions that a phase-out goal raises. These questions include whether we can sell a phase-out without arguing against continued fossil fuel use directly, and how we can move the political process to accept a legitimate role for government more generally. An effort to change the political climate to make a phase-out politically plausible requires answers to these questions.

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112. *See id.*

113. *See* DAVID M. DRIESEN, THE ECONOMIC DYNAMICS OF LAW 36–49 (2012).

114. Hepburn & Stern, *supra* note 105, at 36–37, 43–46; *see also* Banerjee, *supra* note 107.

VI. CONCLUSION

Addressing climate disruption requires a phase-out of fossil fuels. Accepting this proposition reframes the questions we should ask ourselves about how to design effective environmental policy and how to create a political climate where we can adopt sensible policies.

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Nova Law Review
Shepard Broad Law Center
3305 College Avenue
Fort Lauderdale, Florida 33314
Phone: (954) 262-6196
Fax: (954) 262-3845
E-mail: lawreview@nsu.law.nova.edu