CLIMATE POLICY: SEPARATING FACT FROM FANTASY

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There is widespread agreement that climate change is a serious problem. If nations fail to regulate greenhouse gases that contribute to global warming, or use alternative strategies for addressing the problem, the damages could be significant, and perhaps catastrophic. In this Essay, I argue that the range of effective options to address this problem is likely to be quite limited for the foreseeable future. The primary reason is that national leaders appear to lack the political will to achieve global emission reductions in a timely manner.

This observation does not mean that we should do nothing. It does mean that we should focus on what is likely to be sensible and doable. I argue that it makes little sense to try to bring all countries into a binding international agreement to reduce emissions at this time, because such agreements are not likely to be workable. It makes sense, instead, for interested countries to take some action now to limit greenhouse gas emissions, including putting a price on emissions. It also makes sense to focus on research and development — including how best to adapt to climate change, improve our understanding of geoengineering, and improve the cost effectiveness of carbon capture. In addition, countries should continue to experiment with institutions that will be needed to manage a portfolio of solutions for addressing climate change over the longer term. I also note the absence of key political leadership in this area and suggest what is needed.

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I. INTRODUCTION

There is widespread agreement that climate change is a serious problem. If we fail to regulate greenhouse gases that contribute to global warming, or to use alternative strategies for addressing the problem, the damages could be significant, and perhaps catastrophic. Doing nothing to address climate change could result in a loss of almost three percent of world output in 2100 and eight percent in 2200.[1]

The problem of climate change has many features that make it difficult to address. Greenhouse gas emissions do not respect national boundaries. The public good nature of this problem means that each country has an incentive to free ride on the efforts of others, and that widespread cooperation among countries will eventually be needed if we are to make headway on limiting global emissions. It will matter little, for example, if the United States drastically reduces its greenhouse gas emissions if China, India, and the rest of the developing world do not eventually follow suit.[2] Making matters worse, the impacts are likely to vary substantially across countries and regions.[3] The conflict of interests does not only occur between countries, but between generations as well. Many costs of mitigation will be incurred in the near term, while the full benefits of reduced climate change are not likely to be significant for many decades. Furthermore, if mitigation proceeds, it is

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[1] WILLIAM NORDHAUS, A QUESTION OF BALANCE: WEIGHING THE OPTIONS ON GLOBAL WARMING POLICIES 13–14 (2008). This estimated loss includes only damages caused by temperature changes — greenhouse gas-emitting activities such as coal burning also produce health damages associated with local air pollution from soot and sulfur dioxide, which cost China as much as 3.8% of GDP in 2003. THE WORLD BANK & STATE ENVTL. PROT. ADMIN., P. R. CHINA, COST OF POLLUTION IN CHINA: ECONOMIC ESTIMATES OF PHYSICAL DAMAGES, at xiii (2007), *available at* http://go.worldbank.org/FFCJVBTP40.

[2] Developed nations recognize the problem of gaining widespread participation. In the G8 summit on July 8, 2008, they stated for the first time that developing nations would have to be included in any future climate change treaties. The G8 nations committed to cutting their greenhouse gas emissions in half by 2050, but the agreement was short on details, such as the baseline year from which reductions would be achieved and how they would be achieved. This was the first time that President George W. Bush backed an explicit target for reducing greenhouse gas emissions. The countries present at the annual summit included the United States, Britain, Canada, France, Germany, Italy, Japan, and Russia. Sheryl Gay Stolberg, *Richest Nations Pledge to Halve Greenhouse Gas*, N.Y. TIMES, July 9, 2008, at A1.

[3] The costs and benefits of climate change for specific countries will vary. Richer, high-emitting countries such as the United States may find it relatively easy to adapt to climate change, whereas some developing countries, which release relatively small amounts of emissions, will be "the real victims of climate change." Thomas C. Schelling, 2005 Nobel Prize Laureate in Economics and Distinguished Professor, U. Md., Address at the Fourth Annual Hans Lansberg Memorial Lecture: Global Warming: Intellectual History and Strategic Choices (Dec. 6, 2006) (transcript available at http://www.rff.org/Events/Pages/Lansberg-Schelling.aspx); *see also* David Anthoff & Richard J.S. Tol, *On International Equity Weights and National Decision Making on Climate Change* (CESifo Working Paper Series, Working Paper No. 2373, 2008); Cass R. Sunstein, *The Complex Climate Change Incentives of China and the United States* (U. Chi. Olin Law & Econ. Working Paper Series, Working Paper No. 352, 2007); Jason Scott Johnston, *Climate Change Hysteria and the Supreme Court: The Economic Impact on the U.S. and the Misguided Regulation of Greenhouse Gases Under the Clean Air Act* (U. Penn. Inst. Law & Econ., Res. Paper No. 08-04, 2008).

likely to involve regulation of a vast array of different sources and entities.[4] Finally, even with an international consensus, choosing the right policy path may be difficult because the climate change problem is subject to significant uncertainties — projections of greenhouse gas emissions growth from a decade ago are already out of date because of surprisingly rapid economic growth in India and China.[5]

Although climate change is a difficult problem to address, policymakers in developed countries are likely to be forced to pay more attention to the issue as the public becomes more concerned. Europe is already setting new emissions targets for 2020,[6] while U.S. President Obama has pledged to reduce emissions by eighty percent below 1990 levels by 2050.[7]

To date, there has been little progress in reducing greenhouse gas emissions, notwithstanding efforts by a number of countries. Between 1990 and 2005, worldwide emissions of carbon dioxide, a primary greenhouse gas, increased by thirty-two percent, with marked increases occurring in most major countries and regions.[8] This lack of progress raises the critical question of what we should do about climate change. There is no single right answer to this question. In part, the answer should depend on the likely benefits and costs of taking various *feasible* actions. Unfortunately, there is also widespread uncertainty, and disagreement over what the net benefits of various policy measures will be, as well as what may be feasible.

In this Essay, I will argue that even if one believes climate change is a serious problem (as I do), the range of effective options to address this problem is likely to be quite limited for the foreseeable future. Notwithstanding eloquent pleas for substantial emission reductions by leading proponents of

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[4] This is an important difference between the climate change problem and the stratospheric ozone problem, which involved a relatively small number of producers. For a comparison of the two issues, see SCOTT BARRETT, ENVIRONMENT AND STATECRAFT: THE STRATEGY OF ENVIRONMENTAL TREATY-MAKING (2005); Sunstein, *supra* note 3.

[5] *See generally* Ross Garnaut et al., *Emissions in the Platinum Age: The Implications of Rapid Development for Climate-Change Mitigation*, 24 OXFORD REV. ECON. POL'Y 377 (2008). In addition, scientists are still debating a number of important issues, such as whether carbon sinks will be able to soak up more or less carbon dioxide as the temperature increases. More recent evidence suggests that the latter is more likely. *See* Joseph G. Canadell et al., *Contributions to Accelerating Atmospheric CO_2 Growth from Economic Activity, Carbon Intensity, and Efficiency of Natural Sinks*, 104 PROC. NAT'L ACAD. SCI. 18,866 (2007). Therefore, there are major limitations to our ability to predict the effects of a rise in emissions and in atmospheric concentrations of greenhouse gas emissions.

[6] The goals include cutting greenhouse gas emissions by twenty percent (relative to 1990 levels), raising the share of renewable energy in the EU energy supply from 8.5% to 20%, and increasing the share of biofuels in the transportation energy supply to ten percent. Press Release, European Commission, Boosting Growth and Jobs by Meeting Our Climate Change Commitments (Jan. 23, 2008) (on file with the Harvard Environmental Law Review).

[7] Barack Obama & Joe Biden, New Energy For America, http://my.barackobama.com/page/content/newenergy (last visited Apr. 1, 2009) (on file with the Harvard Environmental Law Review).

[8] Energy Info. Admin., U.S. Dep't of Energy, World Carbon Dioxide Emissions from the Consumption and Flaring of Fossil Fuels, 1980–2006, http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls (last visited Apr. 23, 2009) (on file with the Harvard Environmental Law Review).

action such as former U.S. Vice President Al Gore, we are not likely to see dramatic reductions in global net emissions for some time, at least for a decade or more. We will see efforts to move in that direction at the local, national, and international level. But we will not likely see significant results, at least in terms of global emission reductions. The reason is that national leaders appear to lack the political will to achieve significant global emission reductions in a timely manner. Moreover, the institutions and technologies needed to achieve such reductions will take time to develop.

This observation about the politics of climate change does not mean that we should do nothing. The purpose of this Essay is to suggest that we should focus on what is likely to be sensible and doable, with the aim of building the institutional capacity needed to act in as efficient a manner as possible. I argue that it makes little sense to try to bring all countries into a binding international agreement to reduce emissions at this time because such agreements are not likely to be workable. It makes sense, instead, for interested countries to take some action now to limit greenhouse gas emissions, including putting a price on emissions that may increase over time. It also makes sense to focus on research and development, including how best to adapt to climate change, improve the cost-effectiveness of mitigation efforts (such as improving carbon capture and storage techniques), and improve our understanding of geoengineering.[9] In addition, countries should continue to experiment with institutions that will be needed to manage a portfolio of solutions for addressing climate change over the longer term. I also note the absence of key political leadership in this area and suggest what is needed.

The paper proceeds as follows: Part II provides a very brief overview of the science and economics of climate change. Part III addresses the politics. Part IV explores how science, economics, and politics should affect the design of policy. Finally, Part V concludes.

II. Science and Economics: A Very Brief Overview

A. Science

Books have been written about the science of climate change.[10] Here, I simply wish to highlight a few of the key links between greenhouse gas

[9] Geoengineering is understood here as modifying the global climate through affecting the amount of heat absorbed and re-radiated by the Earth without changing the amount of greenhouse gases in the atmosphere. Unlike reducing emissions or capturing and storing carbon, which directly address the cause of global warming, geoengineering techniques such as reflecting more sunlight away from the Earth through solar radiation management, address only certain effects of global warming. *See* Scott Barrett, *The Incredible Economics of Geoengineering*, 39 Envtl. Res. Econ. 45, 45–47 (2008).

[10] *See, e.g.*, Kerry Emanuel, What We Know About Climate Change (2007).

emissions, climate change, and resulting damages to the environment, economy, and standards of living worldwide.

Human activity produces greenhouse gas ("GHG") emissions, most notably carbon dioxide ("CO_2"), but also a host of other gases, including methane, nitrous oxide, perfluorocompounds, and hydrofluorocarbons.[11] These emissions accumulate in the atmosphere. The rate of accumulation is affected by the rate at which sinks, such as forests and oceans, remove carbon as part of the carbon cycle. The greenhouse gases in the atmosphere act as a selective barrier — they allow short-wavelength radiation from the sun to reach and be absorbed by the Earth, but they absorb part of the long-wavelength radiation from the Earth and radiate it back.[12] This process causes the Earth to get warmer. Warming then affects climate, which affects humans, other animals, and plants through events such as sea level rise, droughts, and floods. GHG emissions from human activities are expected to grow by twenty-five to ninety percent between 2000 and 2030 if no major policy changes are made.[13]

The impacts of climate change are difficult to predict with precision. Scientists believe that global warming will affect ecosystems and human life around the world through changes in sea level and weather. Some impacts are more likely than others — for example, it is "likely" that hurricanes and typhoons will increase in intensity, and "very likely" that the number of hot days and heat waves will increase in most parts of the world.[14]

There is a fair amount of consensus on some key points.[15] The first is that average global temperature is rising.[16] A second point is that humans have increased their greenhouse gas emissions significantly relative to pre-industrial times — between 1970 and 2004, emissions increased by seventy percent.[17] The third key point is that global warming is caused, in part, by the increase in GHG emissions.[18]

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[11] TASK FORCE ON NATIONAL GREENHOUSE GAS INVENTORIES OF THE IPCC, 2006 IPCC GUIDELINES FOR NATIONAL GREENHOUSE GAS INVENTORIES (H. S. Eggleston et al. eds., 2006). Water vapor is also an important greenhouse gas, but in keeping with the Intergovernmental Panel on Climate Change ("IPCC"), we do not include it here. Emanuel notes that global warming will increase the atmospheric concentration of water vapor and reinforce the greenhouse effect. EMANUEL, *supra* note 10, at 27.

[12] EMANUEL at 19–20.

[13] IPCC, FOURTH ASSESSMENT REPORT: CLIMATE CHANGE 2007 SYNTHESIS REPORT 44 (2007) [hereinafter FOURTH ASSESSMENT REPORT SYNTHESIS], *available at* http://www.ipcc.ch/ipccreports/ar4-syr.htm.

[14] *Id.* at 46. The IPCC designates an event as "likely" if the evidence suggests that the probability of occurrence is more than sixty-six percent, and as "very likely" if the probability of occurrence is more than ninety percent.

[15] *See id.* For a very useful assessment of the science that is more accessible, the reader should consult Kerry Emanuel's 2007 book. EMANUEL, *supra* note 10.

[16] Temperature increases are evident throughout the world, especially on land and in the Arctic region. FOURTH ASSESSMENT REPORT SYNTHESIS, *supra* note 13, at 30.

[17] Global annual emissions have grown from 28.7 gigatons (measured in tons of CO_2-equivalent) in 1970 to 49.0 gigatons in 2004. *Id.* at 36.

[18] *Id.* at 37.

In short, scientists are confident that humans have increased average global temperatures, and that human impacts probably extend to other aspects of climate, such as changes in wind patterns.[19] Ocean ecosystems are also likely to be affected by ocean acidification caused by chemical reactions between atmospheric carbon dioxide and seawater.[20]

Over the long run, impacts from climate change could be quite significant, and they will be felt unevenly across the globe. For example, low-lying countries such as Bangladesh, Singapore, and the Netherlands will be seriously affected by rises in the sea level, and poorer countries will have fewer resources for coastal protection.[21] Within societies, elderly groups are likely to be disproportionately affected[22] because they are more vulnerable to respiratory and other health problems associated with changes in temperature, and may have access to fewer resources for adaptation.[23]

Furthermore, we cannot rule out catastrophic scenarios, though less is known about their likelihood. Very unpleasant surprises could include, on a local level, intense heat waves and storms, coastal erosion, widespread forest fires, and on a global level, changes in the Atlantic deepwater circulation and rapid melting of the Greenland and Antarctic ice sheets.[24] In addition, if increases in global average temperature exceed 1.5–2.5°C, between twenty and thirty percent of plant and animal species would be at greater risk of extinction, and "major changes" are expected in ecosystems, biodiversity, and food and water supply.[25] Such scenarios are thought to increase in likelihood as concentrations of GHGs in the atmosphere increase.[26]

B. Economics

Climate change economics is a subject of considerable controversy within the profession. This should not be surprising given the complexity of the problem. The climate change issue could be with us for centuries. It will require cooperation on a global or at least a transnational level to make

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[19] *Id.* at 40.

[20] *Id.* at 52.

[21] Near-term rises in sea level, contrary to popular associations with melting ice caps, are likely to be caused to a much greater degree by expanding seawater due to higher ocean temperatures. *See id.* at 30, 65. There is a lot of uncertainty surrounding whether and how quickly the Greenland and Antarctic ice sheets will eventually melt, but the IPCC supports the claim that the Greenland ice sheet is unlikely to disappear before 2100. *See id*. at 47. For a competing view, see James Hansen et al., *Climate Change and Trace Gases*, 365 PHIL. TRANSACTIONS ROYAL SOC'Y. A 1925 (2007).

[22] FOURTH ASSESSMENT REPORT SYNTHESIS, *supra* note 13, at 52–53.

[23] ANTHONY MCMICHAEL ET AL., HUMAN HEALTH AND CLIMATE CHANGE IN OCEANIA, A RISK ASSESSMENT 21 (2002).

[24] FOURTH ASSESSMENT REPORT SYNTHESIS, *supra* note 13, at 52–53. The IPCC predicted that large abrupt changes in the Atlantic deepwater circulation during the course of the century are "very unlikely," but that it is "very likely" that intense heat waves and storms will become more frequent. *Id*. at 46, 54.

[25] "Likely" increases in extinction risk are predicted with "medium confidence" and changes in ecosystems and biodiversity are predicted with "high confidence." *Id.* at 48.

[26] *See id.* at 69–70.

a significant dent in GHG emissions and concentrations in the atmosphere. There are also considerable scientific, economic, and political uncertainties.

Nonetheless, economists agree on a number of ideas. First, it is useful to introduce a cost-benefit framework for thinking about climate change. That does not mean the results of the cost-benefit analyses should be taken as definitive, but rather they should be used to inform policymakers. That is, it is useful to develop strategies that are likely to maximize expected net benefits. It is also important to identify the likely winners and losers from various policies.

Second, the cost-benefit framework strongly suggests that some action to reduce global emissions is worth undertaking now, provided that a large set of countries would eventually agree to limit emissions. If only a few countries are willing to participate, limiting emissions may not be worth it. William Nordhaus estimates that abatement costs will be 250% higher with a participation rate of only fifty percent (consisting of the United States, China, Germany, Russia, and India) compared to a participation rate of 100% because the cheapest opportunities to cut emissions would not be available.[27] If the top fifteen emitters accounting for seventy-five percent of all emissions participate, abatement costs go up by seventy percent as compared to if all countries participate.[28] Economics also suggests that as damage due to global climate change increases over time, more action will be warranted in the future.[29] Third, economists generally agree that, other things equal, it is useful to have mechanisms that put an explicit price on greenhouse gases, most notably carbon dioxide. Nordhaus, for example, advocates a global tax of $32 per ton of carbon.[30] Nicholas Stern advocates having a market for emission rights in a large group of countries determine the price.[31] A key advantage of a price is that it provides a signal to the marketplace that governments are serious about limiting GHGs and that there is a positive payoff to innovation, at least in the short term. Another advantage of a uniform price is that it encourages the reduction of emissions at a lower cost than other regulatory approaches, such as mandatory standards, because the cheapest forms of emissions control would tend to be used first. In addition, a single price can promote more cost-effective innovation.

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[27] NORDHAUS, *supra* note 1, at 19.

[28] *Id.*

[29] *Id.* at 16. Recent scientific evidence suggests that climate change may be irreversible for one thousand years after zero net emissions have been achieved worldwide. Susan Solomon et al., *Irreversible Climate Change Due to Carbon Dioxide Emissions*, 106 PROC. NAT'L ACAD. SCI. 1704 (2009). Such irreversibilities suggest that more action may be needed now to address climate change.

[30] NORDHAUS, *supra* note 1, at 163–64. All values in this paper are in 2007 dollars unless otherwise stated, adjusted using the Consumer Price Index. All tons in the paper refer to metric tons of carbon, which represents 3.67 metric tons of carbon dioxide.

[31] *See* Nicholas Stern, *The Economics of Climate Change*, 98 AM. ECON. REV. (PAPERS & PROC.) 1, 1 (2008).

Fourth, economists generally believe that there is an important role for government-supported research and development ("R&D") in improving our understanding of climate change issues and our ability to address them.[32] R&D expenditures should not only target mitigation efforts, but also increase our understanding of climate change and help identify cost-effective methods for adaptation.[33]

The economics community is divided on a number of important issues, however. For example, some argue that the discount rate, the social tradeoff between present and future consumption, should be relatively low in order to place more weight on the benefits and costs incurred by future generations.[34] Others argue for a higher discount rate that better reflects market realities.[35] Some suggest that a critical feature of the problem is that there is a non-trivial probability of a big catastrophe in the future, which may mean that more action now is warranted.[36] Others focus on what should be done within a cost-benefit context, even without the specter of such a catastrophe.[37]

Such disagreements notwithstanding, it is important to recognize that there is a fair amount of consensus on the basic framework for analysis. Economic models generally suggest that taking action now — in a way that promotes innovation and cost-effectiveness — is a good idea.

III. Political Realities of Climate Change

There is a fundamental problem with the economic models that are typically used. They tend to ignore, or at least gloss over, political realities. There are two very thorny issues that have not received adequate attention in the debate. The first is that the policies that have been adopted to address climate change are likely to be inefficient, and perhaps very inefficient, from an economic perspective. The second is that there is *no* simple way to get major developing countries, such as India and China, to participate in an agreement. And without their eventual participation, an agreement will be of limited use, and could even be counterproductive.

A. Economic Efficiency in Climate Change Mitigation Is a Mirage

Economists have recognized for some time that climate change agreements are not likely to be economically efficient relative to a situation in

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[32] Kenneth J. Arrow et al., *A Statement on the Appropriate Role for Research and Development in Climate Policy*, Economists' Voice, Feb. 2009, http://bepress.com/ev/vol6/iss1/art6.

[33] *See* discussion *infra* Part IV.B.

[34] *See, e.g.*, Stern, *supra* note 31, at 7.

[35] *See, e.g.*, Nordhaus, *supra* note 1, at 9–11.

[36] *See, e.g.*, Martin L. Weitzman, *The Role of Uncertainty in the Economics of Catastrophic Climate Change* 4 (AEI-Brookings Joint Center, Working Paper No. 11, 2007).

[37] *See, e.g.*, Nordhaus, *supra* note 1, at 143–47.

which all countries agree to participate and use a market mechanism.[38] Thomas Schelling, for example, argues that countries should adopt "policies and measures" rather than hard targets for emission reductions, because this is more likely to be politically feasible.[39] Scott Barrett and Robert Stavins note that there are fundamental tradeoffs between different objectives for a climate agreement such as cost-effectiveness, participation, and compliance.[40] More recently, Lee Lane and David Montgomery have made clear why these inefficiencies are likely to persist given the way institutions evolve over time and as a result of the nature of the climate change challenge.[41]

To better appreciate the politics, consider the rise in the price of oil from $55 per barrel at the beginning of 2007 to $132 per barrel at the beginning of July 2008.[42] If the interest is in reducing oil consumption and imports, there is an obvious solution — tax it. But politicians are reluctant to advocate additional energy taxes of any kind. Instead, they argue for indirect fixes such as higher fuel economy standards for vehicles and subsidies for renewable energy sources. On the supply side, there are contentious issues about increasing the domestic energy supply even though for some of the areas in question there may be no significant externalities that would make the costs exceed the benefits.[43]

Similar problems related to taxation arise elsewhere in environmental policy. Recall that President Clinton tried to introduce a tax on non-renewable energy in 1993, which would have increased energy costs by $508 a year for an average family of four, or about $11 per person a month, and that plan was squelched.[44]

A review of the course of international climate policy reveals that inefficiencies abound. The Kyoto Protocol provides a good example. The Protocol signatories agreed to reduce emissions in industrialized countries by five percent between 2008 and 2012, but the Protocol requires no emission control from countries that could be very big emitters in the future, such as

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[38] By efficiency, I mean policies that maximize the discounted present value of expected net benefits. Problems with this objective will be briefly addressed below. *See infra* Part IV.

[39] THOMAS C. SCHELLING, COSTS AND BENEFITS OF GREENHOUSE GAS REDUCTION 13–14 (1998).

[40] Scott Barrett & Robert N. Stavins, *Increasing Participation and Compliance in International Climate Change Agreements*, 3 INT'L ENVTL. AGREEMENTS: POL. L. & ECON. 349, 351 (2003).

[41] Lee Lane & David Montgomery, *Political Institutions and Greenhouse Gas Controls* 20 (Reg-Markets Center, Working Paper No. 9, 2008).

[42] Energy Info. Admin., U.S. Dep't of Energy, *Weekly All Countries Spot Price FOB Weighted by Estimated Export Volume*, http://tonto.eia.doe.gov/dnav/pet/hist/wtotworldw.htm (last visited Feb. 18, 2009) (on file with the Harvard Environmental Law Review).

[43] The Arctic National Wildlife Refuge in Alaska may be a notable exception to this if the existence value people give this as a pristine area is high enough.

[44] The Clinton Administration estimated that an average family would pay an extra $120 a year in direct taxes and another $200 in indirect costs from businesses (in 1993 dollars). This estimate was disputed as being too low by the American Petroleum Institute. Robert D. Hershey Jr., *Clinton's Economic Plan; Energy Tax's Effect Understated up to 50%, Industry Officials Say*, N.Y. TIMES, Feb. 22, 1993, at A14.

China, Brazil, and Indonesia.[45] Furthermore, some major emitters such as the United States and India chose not to sign or ratify.[46] Nordhaus estimates that efforts under this regime, if efficiently carried out, would result in net benefits of $0.16 trillion, but once the likely inefficiencies are considered, net benefits are likely to fall below zero[47] — that is, it may actually be better to do nothing unless Kyoto is viewed as a necessary but costly first step to creating the needed institutional change. On the other hand, an efficient international climate policy is estimated to yield $3.6 trillion in net benefits,[48] but most if not all of these benefits would likely be enjoyed by developing nations.[49]

As things stand, a few signatories are already having trouble fulfilling their Kyoto commitments. Greece is officially recognized by the independent Compliance Committee as non-compliant. Canada's record has also come under investigation by the Committee.[50] In addition, the choice of 1990 as the base year for determining emission cuts gives some countries an advantage that may not be available in the future. For example, Russia's economic decline in the 1990s[51] and the "radical" economic restructuring of the former East Germany[52] have made it easy for Russia and Germany to meet the targets.

The United States, which has refused to sign any binding treaty that exempts China and India from emission reduction requirements, has had several climate initiatives at the national and sub-national levels. One example is the Regional Greenhouse Gas Initiative ("RGGI"), in which ten states — including Massachusetts, New Jersey, and New York — participate in a

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[45] Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, 37 I.L.M. 22 [hereinafter Kyoto Protocol].

[46] India later acceded to the Kyoto Protocol in 2002. Kyoto Protocol: Status of Ratification, http://unfccc.int/files/kyoto_protocol/status_of_ratification/application/pdf/kp_ratification.pdf (last visited April 24, 2009) (on file with the Harvard Environmental Law Review).

[47] *See* NORDHAUS, *supra* note 1, at 200.

[48] *Id.* A climate policy is efficient if it maximizes the difference between discounted benefits and discounted costs.

[49] Cazorla and Toman find that Latin America, China, India, and African countries will gain no matter whether 1) the developed nations unilaterally enforce emission limits, 2) the developing nations limit their emissions based on projected 2020 levels, or 3) developing countries join the emissions allowances system on a per capita basis. In contrast, net benefits are negative for Europe and the United States in every scenario. Marina Cazorla & Michael A. Toman, *International Equity and Climate Change Policy*, *in* CLIMATE CHANGE ECONOMICS AND POLICY 235, 241–44 (Michael A. Toman ed., 2001).

[50] Compliance Under the Kyoto Protocol, http://unfccc.int/kyoto_protocol/compliance/items/2875.php (last visited Feb. 18, 2009) (on file with the Harvard Environmental Law Review).

[51] Russia's real gross national income per capita did not return to 1990 levels until 2003. Quick Query Selected from World Development Indicators, http://ddp-ext.worldbank.org/ext/DDPQQ/member.do?method=getMembers&userid=1&queryId=135 (last visited Apr. 1, 2009) (on file with the Harvard Environmental Law Review).

[52] Rudiger Dornbusch & Holger C. Wolf, *East German Economic Reconstruction*, *in* THE TRANSITION IN EASTERN EUROPE 155 (Olivier Jean Blanchard, Kenneth A. Froot & Jeffrey D. Sachs eds., 1994).

cap-and-trade program.[53] Another example is California's Global Warming Solutions Act of 2006, which aims to reduce state emissions to 1990 levels by 2020 using cap-and-trade and regulatory standards.[54] These different regulatory efforts in the United States are likely to give rise to serious inefficiencies when compared with a market-based national regime aimed at reducing emissions.[55]

We should not be surprised, of course, that climate policy is going to be highly inefficient. Energy politics involves very powerful interest groups that may promote very inefficient policies.[56] For example, Bruce Ackerman and William Hassler describe how interest group and regional politics led to expensive scrubbing of coal power plants, more stringent regulation of new sources, and dirtier air.[57] The policy that resulted from the Clean Air Act Amendments of 1977 was much more expensive than a least-cost solution that would have employed a market-based approach, such as a sulfur tax or a market in sulfur dioxide allowances. Many similar issues will come to the fore as climate legislation winds its way through Congress. Substantial reductions in GHG emissions below "business as usual" levels will result in higher electricity bills, especially for areas that use coal as a primary fuel in electricity generation. Like other implicit or explicit energy taxes in the United States, the effective outcome of climate legislation is likely to hit the poor harder because a larger share of their income is spent on the basic necessities, such as heating and cooling. Congress will undoubtedly work to reduce some of these impacts, most likely by sacrificing many of the cost-effective aspects of the legislation.

There may also be regional battles related to the expected costs and benefits of different climate policies. One conundrum for U.S. legislators is that some moderate amount of warming is likely to make some parts of the

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[53] Regional Greenhouse Gas Initiative, http://www.rggi.org/about (last visited Apr. 7, 2009) (on file with the Harvard Environmental Law Review).

[54] California Air Resource Board, AB 32 Fact Sheet — California Global Warming Solutions Act of 2006, http://www.arb.ca.gov/cc/factsheets/ab32factsheet.pdf (last visited Apr. 1, 2009) (on file with the Harvard Environmental Law Review). A draft Scoping Plan and implementation timeline between 2009 and 2012 were approved by the Air Resources Board on December 11, 2008. For more details on the Plan, see California Air Resource Board, AB 32 Scoping Plan, http://www.arb.ca.gov/cc/scopingplan/scopingplan.htm (last visited Apr. 1, 2009) (on file with the Harvard Environmental Law Review).

[55] Some argue that such initiatives may stimulate a national or global response. For an analysis of the pros and cons of local initiatives, see Cary Coglianese & Jocelyn D'Ambrosio, Response, *Policymaking Under Pressure: The Perils of Incremental Responses to Climate Change*, 40 CONN. L. REV. 1411 (2008). For an examination of how local initiatives are unlikely to result in a difference in global behavior, see Jonathan B. Wiener, *Think Globally, Act Globally: The Limits of Local Climate Policies*, 155 U. PA. L. REV. 1961 (2007). For an explanation of why fragmented carbon markets are likely to be inefficient, see David G. Victor, *Fragmented Carbon Markets and Reluctant Nations: Implications for the Design of Effective Architectures*, *in* ARCHITECTURES FOR AGREEMENT: ADDRESSING GLOBAL CLIMATE CHANGE IN THE POST-KYOTO WORLD (Joseph E. Aldy & Robert N. Stavins eds., 2007).

[56] *See generally* PIETRO S. NIVOLA, THE POLITICS OF ENERGY CONSERVATION (1986).

[57] BRUCE A. ACKERMAN & WILLIAM T. HASSLER, CLEAN COAL/DIRTY AIR: OR HOW THE CLEAN AIR ACT BECAME A MULTIBILLION-DOLLAR BAIL-OUT FOR HIGH-SULFUR COAL PRODUCERS AND WHAT SHOULD BE DONE ABOUT IT (1981).

country better off.[58] It remains to be seen how these regional differences will play out in the political debate. My guess is that the benefits issue may be less important politically than the cost issue, because many of the benefits are more uncertain and will accrue later in time, perhaps decades from now.[59]

The energy lobbies are already gearing up for future battles. For example, the coal lobby is asking for economic assistance and highlighting the potential impact on coal jobs; the ethanol lobby is overstating the importance of ethanol as a solution for reducing greenhouse gases; and the oil lobby is highlighting the economy-wide costs of a climate agreement.[60] This is, of course, how things work in a representative democracy. But the upshot of this lobbying will mean that climate policies in the United States will be much less efficient than economists would like.

While the United States could end up with a cap-and-trade scheme with a safety valve or cap on allowance prices, there will likely be plenty of distortions introduced as a result of the influential pleadings of special interest groups. If one doubts that fact, consider the allowance trading emission scheme aimed at reducing acid rain, which was passed in 1990.[61] While academics often point to this trading program as a great success because it saved money while improving the environment (and I like to think so since I helped design it), interest group politics played an important role here as well in preventing the most efficient outcome. There was significant support for a clean coal technology program as part of this legislative deal to address the concerns of high-sulfur coal producers; and new sources are still regulated differently from old sources under the Clean Air Act, even though there is no economic or environmental justification for doing so.[62]

These political realities are not unique to the United States. Consider the snappy-sounding "20-20-20" proposal that the European Commission has embarked upon. The members plan to reduce greenhouse gas emissions by at least twenty percent by the year 2020 and raise the renewable share of total energy supply to twenty percent (and that of biofuels to ten percent).[63]

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[58] *See, e.g.*, ROBERT MENDELSOHN, THE GREENING OF GLOBAL WARMING 14 (1999). These parts of the United States include higher-latitude regions and areas where agriculture and timber production are significant economic sectors.

[59] *See* Johnston, *supra* note 3.

[60] For information about the U.S. coal industry lobby's impact on policy, see ACKERMAN & HASSLER, *supra* note 57. For a discussion of the response of the U.S. oil industry to climate change concerns, see JON BIRGER SKJÆRSETH & TORA SKODVIN, *Climate Change and the Oil Industry: Common Problems, Different Strategies*, GLOBAL ENVTL. POL., Nov. 2001, at 43.

[61] 42 U.S.C. § 7651 (2006).

[62] Robert N. Stavins, *What Can We Learn from the Grand Policy Experiment? Lessons from SO_2 Allowance Trading*, J. ECON. PERSP., Summer 1998, at 69, 72.

[63] Press Release, European Commission, *supra* note 6; *see also* Press Release, European Commission, Saving 20% by 2020: European Commission Unveils its Action Plan on Energy Efficiency (Oct. 19, 2006) (on file with the Harvard Environmental Law Review). Australia has embarked on a similar action plan to increase the renewable share of total energy supply to twenty percent by 2020. Its emissions trading scheme is scheduled to begin operations in 2010, with the goal of reducing emissions by sixty percent of 2000 levels by 2050. Australian Government Action on Climate Change Fact Sheet, http://www.climatechange.gov.au/about/

Additionally, they aim to reduce energy consumption by twenty percent by the same year.[64] As Dieter Helm notes, the "2020 20-20-20 package is necessarily a political one."[65] If there is an economic justification for these programs, it should be spelled out clearly using standard tools of economic analysis.[66]

I have suggested that politics will lead to inefficient, perhaps highly inefficient, policies for addressing climate change. Although this claim will not surprise most political scientists and many applied economists, it has important implications for policy that may not be fully appreciated. Economic models that assume policy will be efficient or cost-effective are likely to be off the mark. In particular, other things being equal, we should expect policy costs to be significantly higher than have been estimated.[67] If actual costs are higher than the models estimate, then we should expect fewer policies to pass a cost-benefit test than the models suggest. An important general implication of this insight is that countries should probably be doing *less* to reduce GHG emissions than they otherwise would do in a first-best world.[68] They should also be investing more resources in adapting to climate change than would be needed in the first-best case.

B. Significant Developing Country Participation Is a Mirage in the Short Term

It is conventional wisdom that developing countries need to be part of any solution to limit greenhouse gas emissions for several reasons.[69] The

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publications/fs-overview.html (last visited January 12, 2009) (on file with the Harvard Environmental Law Review).

[64] Press Release, European Commission, *supra* note 63.

[65] Dieter Helm, *Climate-Change Policy: Why Has So Little Been Achieved?*, 24 OXFORD REV. ECON. POL'Y 211, 230 (2008). The same point about politics could be made regarding national climate mitigation efforts in the United States with sound-byte titles, such as "25-25" in the case of Obama's plan for twenty-five percent of the nation's energy to be from renewable sources by 2025; and "20 in 10" in the case of Bush's plan for reducing gasoline use by twenty percent in ten years. Obama & Biden, *supra* note 7; Press Release, Envtl. Prot. Agency, Bush Admin. Establishes Program to Reduce Foreign Oil Dependency, Greenhouse Gases (Apr. 10, 2007) (on file with author); *see also infra* note 114.

[66] Spelling out the full range of economic and environmental impacts may increase the likelihood that such policies will be opposed by various interest groups, and possibly defeated, but I believe it is something that should be done in the interest of good governance.

[67] I do not focus here on whether cost and benefit estimates are unbiased either in an ex ante or ex post sense. This issue is important, but beyond the scope of this Paper. *See, e.g.*, Winston Harrington, Richard D. Morgenstern & Peter Nelson, *On the Accuracy of Regulatory Cost Estimates*, 19 J. POL'Y ANALYSIS & MGMT. 297 (2000).

[68] I emphasize that this insight depends on the accuracy of the models that are used to estimate benefits and costs. If, for example, the models tended to overstate actual costs, then this bias would push in the opposite direction. See Robert W. Hahn & Paul C. Tetlock, *Has Economic Analysis Improved Regulatory Decisions?*, 22 J. ECON. PERSP. 67, 77 (2008) for a discussion of possible biases in estimates of the costs and benefits of regulation.

[69] While countries like China and India are still much lower than the United States in terms of per capita emissions, their aggregate emissions are substantial. In terms of equity, these countries argue that they should not be shouldered with the burdens of the past, because they did not contribute as much to the stock of greenhouse gases. For an examination of equity

first reason is that they are already significant contributors to the emissions problem.[70] China, which builds approximately two large coal-fired power plants every week,[71] is already the world's leading emitter of CO_2, followed by the United States.[72] India is the fifth largest emitter, behind Russia and Japan.[73] The gap between United States and Chinese annual emissions is projected to grow rapidly in the next twenty years under a business-as-usual scenario, as Figure 1, *infra*, indicates. By some estimates, non-Annex I emissions will overtake Annex I emissions within the next decade.[74] By 2030, China and India together are expected to account for about thirty-five percent of world CO_2 emissions.[75] Adding in the other developing countries leads to a number on the order of sixty-five percent.[76]

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issues, see Eric A. Posner & Cass R. Sunstein, *Should Greenhouse Gas Permits Be Allocated on a Per Capita Basis?* (Univ. of Chi. Law Sch. Pub. Law & Legal Theory Working Paper Series, Paper No. 206, 2008).

[70] Not all emissions are thought to lead to global warming. Sulfate particles, for example, have a transient cooling effect on the climate, even as they cause other environmental problems like acid rain. Paul J. Crutzen, *Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Solve a Policy Dilemma?*, 77 CLIMATIC CHANGE 211, 211 (2006).

[71] China has increased its coal-powered plant capacity by 90 gigawatts in 2006, which is equivalent to building about two large coal power plants a week. About eighty percent of China's electricity is generated using coal. Pew Ctr. on Global Climate Change, Coal and Climate Change Facts, http://www.pewclimate.org/global-warming-basics/coalfacts.cfm (last visited Feb. 18, 2009) (on file with the Harvard Environmental Law Review). In addition, these coal power plants, which will likely operate for several decades, are not being constructed in a way that allows them to easily take advantage of carbon capture and storage technologies in the future.

[72] Press Release, Neth. Envtl. Assessment Agency, China Now No. 1 in CO_2 Emissions; USA in Second Position (June 19, 2007) (on file with the Harvard Environmental Law Review). There are no national data on China's emissions.

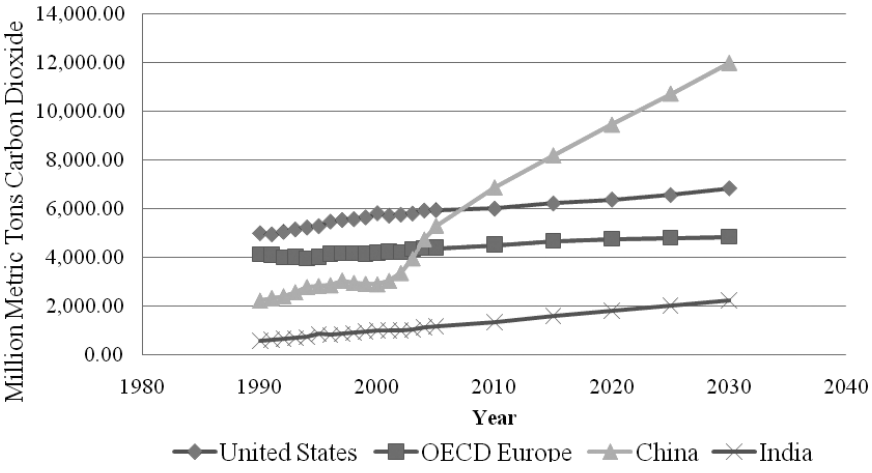
[73] Energy Info. Admin., U.S. Dept't of Energy, World Carbon Dioxide Emissions from the Use of Fossil Fuels, http://www.eia.doe.gov/iea/carbon.html (last visited Apr. 7, 2009) (on file with the Harvard Environmental Law Review).

[74] Govinda R. Timilsina, *Atmospheric Stabilization of CO2 Emissions: Near-Term Reductions and Absolute Versus Intensity-Based Targets*, 36 ENERGY POL'Y 1927, 1930 (2008).

[75] The precise estimate is 33.7%. ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, INTERNATIONAL ENERGY OUTLOOK 2006, 93 tbl.A10 (2008), *available at* http://www.eia.doe.gov/oiaf/archive/ieo06/pdf/0484(2006).pdf.

[76] The precise estimate is 59.9%. *Id.*

FIGURE 1: HISTORICAL AND PROJECTED CO_2 ANNUAL EMISSIONS BY COUNTRY, 1990-2030[77]



Note: All values before 2005 are historical. All values past 2005 are projections. Carbon dioxide emissions refer to emissions from fossil fuels, except in the case of projected U.S. emissions, which include emissions from renewable resources.

The second reason is that there are many opportunities for cost-effective net emission reductions in developing countries. For example, it may be relatively inexpensive to pay these countries not to cut down carbon-absorbing forests.[78]

The third reason is that imposing carbon restrictions only in developed countries would give a relative advantage to dirtier, unregulated industries in developing countries. This would in effect be subsidizing the growth of dirty industries, making regulation less effective. It would also make regulation less politically attractive for those developing countries that might be considering costly climate change controls.

Despite the importance of developing countries' involvement in an international climate agreement, absent subsidies or side payments, many, such as China and India, do not perceive it in their interest to sign an agreement today that would require them to take costly actions. A key reason that

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[77] Historical data obtained from Energy Info. Admin., Dep't of Energy, International Energy Annual 2006 (Dec. 8, 2008), http://www.eia.doe.gov/pub/international/iealf/tableh1co2.xls (last visited Apr. 23, 2009) (on file with the Harvard Environmental Law Review). Projections obtained from ENERGY INFO. ADMIN., DEP'T OF ENERGY, INTERNATIONAL ENERGY OUTLOOK 2008 (2008), *available at* http://www.eia.doe.gov/oiaf/ieo/pdf/0484(2008).pdf. Values for OECD Europe calculated by author.

[78] *See, e.g.*, Georg Kindermann et al., *Global Cost Estimates of Reducing Carbon Emissions Through Avoided Deforestation*, 105 PROC. NAT'L ACAD. SCI. 10,302 (2008). The researchers point out that this approach leads to additional benefits, such as improved local water quality and increased biodiversity protection. However, their cost estimates do not account for the likely problem of leakage.

major developing countries such as China and India may object to an agreement with required emission reductions is that it is likely to limit their development opportunities. They recognize that there is a critical relationship between energy use and growth, and they see reducing carbon dioxide emissions as raising the cost of doing business, and hence reducing their economic growth.[79] They are not willing to sacrifice growth today for the benefit of future generations, who can be expected to have greater economic resources.[80] The bottom line is that we should expect most major developing countries to refrain from entering into any binding agreements where they are expected to help shoulder a major portion of the bill.

The economics literature explores essentially four key ways to encourage such developing countries to participate in a binding agreement.

1. *Let them do what they want*: Countries may announce policies or intentions, but these actions are not binding in a legal sense. If developing countries are allowed to do what they want, this has the advantage that they will comply with the agreement (by definition), but it has the distinct disadvantage that they may not do very much.

2. *Ask them to join when they are richer*: A variant of the first mechanism is to let developing countries do what they want until they get rich enough. Once the per capita income in a country exceeds a certain amount, they will be asked to make mandatory reductions in GHGs. A critical problem with this opt-in mechanism is that it is still voluntary — that is, there are no clear costs of non-compliance, and therefore it is not credible that they will join in the future. That, in turn, makes it less likely that OECD nations will make much investment in costly low carbon policies today or in the future. Even if a developing country says it will opt in when it is richer, there is no guarantee that it actually will fulfill its promise, nor are there ways to force it to do so.

3. *Make it cheaper for them to participate or pay them to join*: Some developing countries may feel that it would be unfair for them to pay for emissions control when the opportunity cost is higher for them — the same dollar, for example, goes a longer way toward improving life expectancy in India than in Europe. One solution is to lower their costs by offering technological transfers and providing them with a working market-based system for emissions control. The two may be connected. For example, suppose some countries impose a carbon tax. This could stimulate technological change that makes reducing emissions cheaper, which might induce more countries to participate. Another approach to improving technology is for a subset of countries to fund research and development efforts. I will argue

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[79] *See, e.g.*, BRUCE BERKOWITZ, STRATEGIC ADVANTAGE: CHALLENGERS, COMPETITORS, AND THREATS TO AMERICA'S FUTURE 44 (2008). Berkowitz argues that there is a strong connection between energy utilization and output. *Id.*

[80] *See, e.g.*, Thomas C. Schelling, *Some Economics of Global Warming*, 82 AM. ECON. REV. 1, 11 (1992). Another reason developing countries may prefer not to be parties to an agreement is because it may give them a competitive advantage.

below that both a price-based approach and research and development should be pursued by those countries interested in doing so. However, countries should recognize that such an approach is not likely to increase the willingness of some developing countries to join treaties in the short run.

Some scholars have argued that cash or in-kind transfers may be necessary to induce participation.[81] There are at least three problems with this option. The first is that the side payments could be substantial. Jacoby et al. estimate that transfers from the developed world to developing countries would be on the order of $500 billion per year, reaching a total of $4 trillion by 2050.[82] The second is that side payments may be used to increase polluting activities in developing countries, and hence payments should be conditional and/or made in kind, preferably using climate-friendly technology.[83] Even so, side payments may not go for the intended purpose. There are many cases, for example, where development aid has not been fully allocated for its intended purpose as a result of corruption or mismanagement. Furthermore, even when it is allocated to the intended activity, it may not be spent effectively. A third problem in the case of ex ante lump sum side payments, at least from the standpoint of the donor countries, is that they may be used as strategic tools. Imagine, for example, that China is paid for the first decade to install nuclear plants instead of coal plants to increase its energy supply. China then could demand an exorbitant payment (at least from the viewpoint of the donor countries) to continue this strategy in the second decade. While such hold-up problems can be mitigated, they are a central feature of the climate problem, and may not easily be reduced at a reasonable cost. Large payments may also create perverse incentives for other countries that were initially willing to cooperate for free, thereby producing counterproductive results.[84]

In-kind transfers can be built into a market scheme, but this may not make them any more palatable. For example, one suggestion put forth by India has been to allocate emission rights on a per capita basis, which may result in U.S. net transfers to foreign governments on the order of $141 billion a year.[85]

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[81] *See, e.g.*, Carlo Carraro, Johan Eyckmans & Michael Finus, *Optimal Transfers and Participation Decisions in International Environmental Agreements*, 1 REV. INT'L ORG. 379, 386-87 (2006).

[82] HENRY D. JACOBY ET AL., SHARING THE BURDEN OF GHG REDUCTIONS 15 (2008), *available at* http://globalchange.mit.edu/files/document/MITJPSPGC_Rpt167.pdf. The United States would be footing approximately forty percent of this bill, which comes to a total of $1.5 trillion by 2050.

[83] There is a basic problem related to establishing a baseline for emission reductions and making measurements. *See, e.g.*, Carsten Schmidt, *Incentives for International Environmental Cooperation: Theoretical Models and Economic Instruments*, *in* INTERNATIONAL ENVIRONMENTAL ECONOMICS 209, 222-27 (Günther G. Schulze & Heinrich W. Ursprung eds., 2003).

[84] Michael Hoel & Kerstin Schneider, *Incentives to Participate in an International Environmental Agreement*, 9 ENVTL. & RES. ECON. 153, 167 (1997).

[85] The estimates were made based on an assumption of $100 per ton of carbon emissions (in 2001 dollars) to keep per capita emissions at twenty-four tons per year and updated to 2007 dollars. Such a calculation is overestimated because it ignores the substitution effect, and

One short-term way of addressing the side payment issue is to allow some developing countries to participate in a global trading system on a project-by-project basis. So, for example, a developed country might pay for preserving or planting a forest in a developing country that would serve as a store of CO_2. This is the idea behind the Clean Development Mechanism ("CDM").[86] It was developed as a way of helping Kyoto signatories reduce their costs of meeting CO_2 limits. A fundamental problem with project-by-project approaches is that they are susceptible to manipulation relatively easily. In particular, it is impossible to observe the actual impact on emissions of a particular project, even within a country. Suppose, for example, a forest is saved in one part of a country, but as a result, another forest not covered by the program was cut down elsewhere. The net result could be a wash for emissions, even though the project could narrowly be said to have reduced CO_2 by preserving the forest. It can also be fairly difficult to prove that the forest was not preserved for other economic or noneconomic reasons.

This problem is a familiar one to students of market-based environmental policy. It arose in the 1970s when the United States began implementing an "offset" policy.[87] While there are ways of addressing this problem, such programs are likely to have limited usefulness for actually making a serious dent in countrywide emissions. They may, however, help countries to build an institutional capability for seriously addressing the GHG problem down the road.[88]

4. *Make them pay if they do not join*: Making developing countries pay may sound good on the surface, but this approach has problems. One potentially attractive form of negative incentive is to impose trade sanctions or tariffs on the carbon footprint of imports from countries that do not cooperate. In this way, industries in non-participating countries do not gain a cost advantage, and foreign governments are punished because they lose the potential revenue from taxes being extracted from their exports. There are three major problems with such sanctions or tariffs. First, it may not be easy to determine the carbon footprint of a large number of imports. The U.S. Commerce Department has a poor record in its ability to correctly estimate the production costs of foreign-made goods that compete with American

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because the carbon price may be too high. Richard N. Cooper, *The Kyoto Protocol: A Flawed Concept* 13 (FEEM Note di Lavoro Series, Working Paper No. 52, 2001). For a critique of the per capita approach to allocating emissions, see Posner & Sunstein, *supra* note 69.

[86] Kyoto Protocol, *supra* note 45, art. 12.

[87] *See, e.g.*, RICHARD A. LIROFF, REFORMING AIR POLLUTION REGULATION: THE TOIL AND TROUBLE OF EPA'S BUBBLE 124 (1986).

[88] See Michael W. Wara & David G. Victor, *A Realistic Policy on International Carbon Offsets* (Stanford Program on Energy & Sustainable Dev., Working Paper No. 74, 2008) for an insightful analysis of the CDM. The authors point out that the CDM may reduce incentives for countries to agree to global limitations on emissions and to focus instead on emissions-reducing investments that are most likely to pass as "additional."

goods.[89] Second, participating countries may stand to lose more from limiting free trade or even just threatening to do so than they stand to gain from a global climate treaty. For example, if a country is already expecting to reap very modest net benefits from imposing limits on greenhouse gases, sanctions could tip the decision from one of participating to one of not participating in such an agreement. Thus, sanctions may not represent a credible threat.[90] Third, sanctions may violate World Trade Organization ("WTO") principles.[91]

Joseph Aldy, Peter Orszag, and Joseph Stiglitz suggest the use of much less costly social sanctions, which may include boycotting or disbarring uncooperative countries from international sporting events, encouraging domestic consumers to boycott their products, and barring their representatives from major seats in international organizations.[92] These actions, however, have costs of their own, as they may reduce international goodwill and will decrease the number of political instruments available to the sanctioning countries.

Although the preceding list has been written with respect to major developing countries, it applies to any country that does not believe it would be in its interest to sign an agreement. At this point, I am not aware that anyone has "solved" the problem of developing (or developed) country participation or the even harder problem of ensuring compliance. This is because they are hard problems. Compared to other international agreements like the Montreal Protocol, a carbon emissions-controlling treaty would be considerably more expensive — CO_2, unlike halogenated hydrocarbons, is involved in most industrial processes, and there are fewer substitutes.

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[89] Brink Lindsey, *The U.S. Antidumping Law: Rhetoric Versus Reality* 6–7 (Cato Inst. Ctr. for Trade Policy Studies, Trade Policy Analysis No. 7, 1999).

[90] *See, e.g.*, Barrett & Stavins, *supra* note 40, at 370; Scott Barrett, *The Credibility of Trade Sanctions in International Environmental Agreements*, *in* TRADE, GLOBAL POLICY, AND THE ENVIRONMENT 161, 169 (Per G. Fredriksson ed., 2000).

[91] Steve Charnovitz, *Trade and Climate: Potential Conflicts and Synergies*, *in* BEYOND KYOTO: ADVANCING THE INTERNATIONAL EFFORT AGAINST CLIMATE CHANGE 141, 157 (Pew Ctr. on Global Climate Change ed., 2003). This remains an open issue, with other scholars arguing that border taxes on carbon could be within WTO laws. *See, e.g.*, Joost Pauwelyn, *U.S. Federal Climate Policy and Competitiveness Concerns: The Limits and Options of International Trade Law* 41–44 (Nicholas Inst. for Envtl. Policy Solutions, Working Paper No. 07-02, 2007). Some analysts have suggested targeted sanctions against particular countries, such as China. It is unlikely that such sanctions would work. China could simply divert some of its exports going to the United States to other countries. Then, other countries with similar products could export them to the United States. The point is that sanctions or tariffs would need to be fairly comprehensive to have a chance of working, and they would need to be imposed by a group of countries that represent a significant part of the world economy. Even with such an approach, there are likely to be serious economic risks associated with a move away from freer trade.

[92] Joseph E. Aldy, Peter R. Orszag & Joseph E. Stiglitz, Presentation at the Timing of Climate Change Policies Conference: Climate Change: An Agenda for Global Collective Action 14–15 (Oct. 2001); *see also* Robert O. Keohane & Kal Raustiala, *Toward a Post-Kyoto Climate Change Architecture: A Political Analysis* 3–5 (Harvard Project on Int'l Climate Agreements, Discussion Paper No. 08-01, 2008).

But if we find that it is going to be extremely difficult and/or expensive to bring rapidly growing developing countries — particularly the large emitters — into a meaningful climate agreement in the near future, then this has important policy consequences. First, we should not assume that these countries will join an agreement that would force them to depart significantly from their preferred growth strategies anytime soon. Indeed, the evidence strongly suggests that most of them will not, unless there is a substantial change in the way the climate change issue is viewed or in the cost of making emission reductions.[93] The best we may hope for is that these developing countries may lower carbon emissions voluntarily in ways that also benefit them, such as increasing energy efficiency or investing more in nuclear power. Second, if these countries do not join and other countries do limit their emissions, the carbon-intensive industries will be expected to move to the pollution havens (those countries without regulation),[94] and this economic and political problem should be taken into account in any policy analysis and modeling. Third, a critical factor that developed countries will want to consider in designing policies is how those policies will affect the probability that key developing countries, such as China and India, will agree to limit their GHG emissions later. Encouraging firms to export their pollution to these developing countries would increase the carbon intensity of their economies, making future treaty agreements more difficult to achieve.[95]

The review in this Part strongly suggests that there are likely to be major problems in reducing global greenhouse gas emissions efficiently. These problems arise for at least two reasons. First, domestic energy politics will constrain the approaches that particular countries will take to reducing emissions. Second, it is highly unlikely that the major developing countries will do much for the foreseeable future, unless they receive substantial side payments, which is unlikely.[96]

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[93] The United States may not be ready to make technological concessions either — President Bush recently rejected a climate fund proposal put forth by China that would allow developing countries to buy patent rights of climate-friendly technologies. Erika Engelhaupt, *Who Will Pay for a Global Climate-Technology Revolution?*, 42 ENVTL. SCI. & TECH. 1819, 1820 (2008).

[94] Most economic models show that the implementation of the Kyoto Protocol under the current regime would likely lead to carbon leakage on the order of five to twenty percent. FOURTH ASSESSMENT REPORT SYNTHESIS, *supra* note 13, at 59. Mustafa Babiker, on the other hand, estimates that leakage rates could be as high as 130% in oligopolistic energy-intensive industries, causing some GHG control policies to be counterproductive. Mustafa H. Babiker, *Climate Change Policy, Market Structure, and Carbon Leakage*, 65 J. INT'L ECON. 421, 441 (2005); *see also* Arik Levinson & M. Scott Taylor, *Unmasking the Pollution Haven Effect*, 49 INT'L ECON. REV. 223 (2008) (assessing the impact on North America).

[95] Jonathan B. Wiener, *Incentives and Meta-Architecture*, *in* ARCHITECTURES FOR AGREEMENT: ADDRESSING GLOBAL CLIMATE CHANGE IN THE POST-KYOTO WORLD, *supra* note 55, at 67, 69.

[96] Richard Tol et al. remark that "in practice there is indeed no Pareto improving transfer scheme possible." Richard J.S. Tol et al., *Technology Development and Diffusion and Incentives to Abate Greenhouse Gas Emissions* 1, 2 (Research Unit Sustainability & Global Change, Working Paper No. 6, 2001); *see also* Barrett & Stavins, *supra* note 40.

IV. A United States or Developed Country Policy That Makes Sense

This Part lays out a program that the United States, and possibly other developed countries, might consider in light of the difficulties discussed above. Before laying out what I see as key elements, I want to make a few remarks about the appropriate objective for climate policy. One objective might be to devise a set of policies that maximizes the difference between expected economic benefits and costs, taking into account the kinds of political realities that were noted in the preceding Part. In some cases, however, particularly where there is a non-trivial probability — perhaps unknown — that current climate policy could result in catastrophe some time down the road, perhaps much greater action is needed.[97] We do not have a clear sense of how large this probability may be, but the direction we should be moving in now is reasonably clear — we should be doing more. How much more action depends on assumptions about society's attitudes toward risks, the nature of the consequences, and their probabilities.[98]

For present purposes, this debate is not central, though I think it is very important for long-term policy. For example, if one believes that the probability of a catastrophe is high, and the costs of a catastrophe are enormous, there may be a rationale for throwing the "kitchen sink" at the problem.[99] For now, though, we have barely thrown anything at the problem, and the critical question facing politicians is what reasonable next steps in the real world might look like.

Let me begin with reducing emissions. The most important thing that the United States can do is to explore ways of bringing in a sizable coalition of countries over the medium and long term to actually reduce their GHG emissions. There is not one best way to accomplish this objective. Some argue for global agreements and others for bottom-up approaches. My own view is that international agreements are likely to be largely symbolic at this point in time, though developed countries may want to engage in agreements that limit emissions. Such agreements could help to establish a framework for reviewing progress on emission reductions and monitoring compliance with specific targets or goals.

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[97] *See, e.g.*, Alan S. Manne & Richard G. Richels, Buying Greenhouse Insurance: The Economic Costs of Carbon Dioxide Emission Limits (1992); Weitzman, *supra* note 36.

[98] Even when there is a rationale for doing more because of potential catastrophes, economics can sometimes provide guidance as to how much more.

[99] *See* Richard A. Posner, Catastrophe: Risk and Response 245–65 (2004); Edward A. Parson, *The Big One: A Review of Richard Posner's* "Catastrophe: Risk and Response," 45 J. Econ. Literature 147, 148 (2007). If the concern is with the upper tail of the distribution, there are at least two ways to reduce risks. One is to try to move the distribution to the left by engaging in a major mitigation initiative. This would be quite costly. A second way is to consider buying some time through geoengineering, which also has its risks.

My preferred solution or policy proposal for the United States has three components. First, the United States should put a modest price on carbon using some kind of market-based mechanism, such as a tax or marketable permits. Second, the United States should perform a serious reassessment of its research and development priorities. Third, the President of the United States should consider exercising greater leadership on climate change.

A. National Carbon Price

There are three reasons for putting a modest price on carbon. First, it shows the United States is serious about moving in the direction of reducing its own emissions. This, in itself, should stimulate cost-effective innovation, especially if the United States could *credibly* commit to such a program for the next decade or two. Second, a modest price can be implemented with the promise of higher prices in the future *if* other key countries agree to join an agreement (China, India, and so forth). This is what the EU has set out to do, by pledging to reduce GHG emissions by a total of thirty percent, up from its current target of twenty percent, if other countries join the efforts.[100] Third, because price mechanisms can be cost-effective if implemented judiciously, this is a good institutional framework to have in place to help insure relatively low-cost emission reductions over the longer term.

Economists like to argue about whether setting prices (read: taxes) or quantities (read: allowance trading regimes) is better. I think that the reality in the United States now is that politicians are not very comfortable with the word "tax," at least emission taxes. A courageous politician or president could propose a carbon tax that substituted for other less efficient taxes. I do not think that will happen any time soon.[101]

More likely, and still attractive, is a national emissions allowance trading regime, similar to the one we have for sulfur dioxide ("SO_2"), where one allowance permits the emission of one ton of carbon or its equivalent.[102] A national carbon trading program, which could either add to or absorb current efforts, would strive to equalize the marginal costs of regional programs such as the Regional Greenhouse Gas Initiative and Western Climate Initiative, producing a relatively efficient outcome. If the United States implements such a regime for controlling GHGs, it is important to introduce a safety valve or price ceiling on the marginal cost of control, thus providing firms with more certainty.[103]

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[100] Press Release, European Commission, *supra* note 6.

[101] Taxes have the advantage of making the costs of addressing climate change more transparent. In that sense, the public is less likely to support a program it may not want. Taxes may also be less prone to unforeseen consequences, such as corruption. *See, e.g.*, NORDHAUS, *supra* note 1, at 159–61.

[102] *See* Clean Air Act § 401, 42 U.S.C. § 7651 (2006).

[103] *See generally* Henry D. Jacoby & A. Denny Ellerman, *The Safety Valve and Climate Policy*, 32 ENERGY POL'Y 481 (2004).

The United States may be on the verge of passing legislation that would establish a national price for carbon emissions. Several pieces of legislation introduced in the last two years require carbon emissions to be priced by an allowance trading system. However, these proposed initiatives may prove to be quite expensive. According to projections from the Environmental Protection Agency, the Low Carbon Economy Act of 2007 would increase electricity bills by twenty percent and raise gasoline prices by $0.22 in 2030. A more recent bill, the Climate Security Act of 2008, imposes even more severe costs on the economy — electricity prices are expected to increase by forty-four percent and gas prices are projected to increase by $0.53 in 2030.[104]

New legislation is not guaranteed. If Congress cannot pass new legislation, then the Clean Air Act could be used to regulate greenhouse gas emissions.[105] The problem with this approach is that the Act was not designed with the regulation of GHGs in mind. For example, using the Act to regulate GHGs could result in the regulation of very small sources of pollution such as schools and shopping malls. In addition, the Clean Air Act does not include a simple mechanism to ensure that emission reductions will be cost-effective. Indeed, there is a distinct possibility that using the Act could result in a sector-by-sector approach to regulation that takes a long time to implement and is very wasteful. If the Clean Air Act were not used, the President could issue an executive order instructing federal agencies to use a shadow price for GHGs in their decision making.[106] This approach also suffers from the fact that it is piecemeal, and will only address sources covered by newly proposed regulations. Furthermore, it will be constrained by existing law.

One of the problems with the current crop of legislative proposals is that they may imply politically unacceptable price increases. If that is the case, setting a lower price for carbon by increasing the number of allowances available would be more palatable. Suppose, for the sake of illustration, that the number of allowances put on the market is chosen so that the

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[104] Over the long run, the economic costs are likely to rise. For example, in 2050, gasoline prices are projected to rise by $0.55 under the Low Carbon Economy Act and by $1.34 under the Climate Security Act. *See* U.S. ENVTL. PROT. AGENCY, EPA ANALYSIS OF THE LOW CARBON ECONOMY ACT OF 2007, at 3-4 (2008), *available at* http://www.epa.gov/climatechange/economics/pdfs/S1766_EPA_Analysis.pdf; U.S. ENVTL. PROT. AGENCY, EPA ANALYSIS OF THE LIEBERMAN-WARNER CLIMATE SECURITY ACT OF 2008, at 2–3 (2008), *available at* http://www.epa.gov/climatechange/downloads/s2191_EPA_Analysis.pdf. These estimates are based on a projected producer price of $55 per barrel of oil in 2030, based on the Energy Information Administration's 2006 forecasts. The 2008 forecasts project significantly higher prices for crude oil and natural gas and slower growth in energy demand, which implies lower national emissions.

[105] The Supreme Court ruled in 2007 that GHGs meet the definition of air pollutants and, if EPA makes the requisite endangerment finding, should be regulated under the Clean Air Act. Massachusetts v. EPA, 549 U.S. 497 (2007). For a discussion of the implications of this ruling, see Jonathan H. Adler, *Warming Up to Climate Change Litigation*, 93 VA. L. REV. IN BRIEF 61 (2007).

[106] The shadow price for GHGs can be thought of as the marginal cost in damages of an additional ton of GHG emissions.

price is about $15 per ton of carbon-equivalent. A safety valve could then be set at $20 per ton.[107] If the price of an allowance hit the safety valve price, then the U.S. government could simply sell allowances at that price. It is also reasonable to have a price floor to stimulate innovation in emissions reduction by assuring that reductions in greenhouse gas emissions will fetch a positive price. Perhaps the price of an allowance would not be allowed to fall below $10 per ton of carbon, with the government intervening on the buy side at that point. The price may increase in real terms over time to reflect the rising costs of climate change and the need to cut emissions more sharply in the future.[108]

In effect, the regime I am recommending is a mixed price-quantity system.[109] If the government does raise revenues by auctioning some or all of the allowances, it would be desirable for them to be spent wisely, but whether they will be is debatable, given the political pressures on spending newfound sources of revenue.[110] These pressures are likely to be even greater in the current financial climate, where a serious recession appears to be imminent.

The system I have in mind would steer away from mandated standards and subsidies. Neither of these tools is particularly well-suited for generating cost-effective innovation addressing the problem of climate change. Standards may be effective in limited situations where the technological solution is reasonably clear, but they are unlikely to result in major breakthroughs.[111] The regulator typically lacks the kind of information needed to set standards appropriately for forcing innovation. I would also suggest avoiding subsidies for particular fuels or technologies.[112] Unfortunately,

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[107] Richard Tol finds the mean of the social cost of carbon in the economics literature to be around $31 per ton in 2000. Richard S.J. Tol, *The Social Cost of Carbon: Trends, Outliers and Catastrophes*, ECON.: OPEN-ACCESS, OPEN-ASSESSMENT E-JOURNAL, Aut. 2008, http://www.economics-ejournal.org/economics/journalarticles/2008-25 (on file with the Harvard Environmental Law Review).

[108] The real rate of increase of the optimal tax would be around two or three percent per year. NORDHAUS, *supra* note 1, at 16.

[109] *See, e.g.*, Marc J. Roberts & Michael Spence, *Effluent Charges and Licenses Under Uncertainty*, 5 J. PUB. ECON. 193 (1976) for an early discussion. *See also* ROBERT W. HAHN, THE ECONOMICS AND POLITICS OF CLIMATE CHANGE 37–55 (1998) (discussing the price ceiling and floor in the context of climate change.

[110] Auctions are generally preferable to grandfathering or giving away permits to firms based on their historical levels of emissions, *provided* the revenues are spent wisely. *See* Peter Cramton & Suzi Kerr, *Tradable Carbon Permits: How and Why to Auction Not Grandfather*, 30 ENERGY POL'Y 333 (2002); *see also* Robert W. Hahn, *Greenhouse Gas Auctions and Taxes: Some Practical Considerations*, 3 REV. ENVTL. ECON. & POL'Y (forthcoming 2009).

[111] In certain situations command-and-control regulation may be better than market-based instruments. A recent United Nations Environment Programme ("UNEP") study, for example, finds that building codes are more effective and less costly than market-based instruments for increasing energy efficiency in buildings. Press Release, UNEP, Regulation Key to Greener Buildings (Sept. 24, 2007) (on file with the Harvard Environmental Law Review). Theory and experience, however, tend to suggest otherwise. *See, e.g.*, THOMAS H. TIETENBERG, EMISSIONS TRADING: PRINCIPLES AND PRACTICE (2nd ed. 2006).

[112] Although subsidies may be appropriate in cases where the technology leads to learning, such subsidies have tended to be highly politicized.

Congress may be moving in this direction. The Energy Independence and Security Act, passed in 2007, introduces a host of new mandates, including higher Corporate Average Fuel Economy ("CAFE") standards affecting automobile energy efficiency and requiring fuel production to include at least thirty-six billion gallons of biofuels in 2022.[113] It remains to be seen how legislation that specifically targets climate change will be shaped, although it is very likely that command-and-control regulations will be an important part of it.[114]

A challenging feature of setting a national price, which would be better than pervasive command-and-control regulation, will be to create a stable long-term commitment. To reduce rent seeking and promote innovation, entrepreneurs need to face a stable set of prices over time, with fairly well-defined rules of the road. This can be done through careful legislative design — for example, designing a trading system with clear property rights over a decade or two. The idea would be to make it politically costly to reverse the legislation.[115] Of course, if the climate problem appears to get worse over time, that in itself will likely make it more difficult for politicians to reverse course.[116]

The perceptive reader will note that my proposal could possibly increase net global greenhouse emissions in the short term, if firms move enough carbon-intensive activities to regions that are less regulated or not regulated at all.[117] The alternative of trying to bring many or most countries into a binding agreement now is likely to be unfeasible, in part because of

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[113] Energy Independence and Security Act of 2007, Pub. L. No. 110-40, 121 Stat. 1492 (codified in several volumes of the U.S.C.). Out of ten cap-and-trade bills introduced in the 110th Congress, four include setting efficiency or performance standards for vehicles and/or industry. See Lane & Montgomery, *supra* note 41, for an excellent analysis of new regulatory initiatives in the United States and Europe.

[114] President Obama has proposed initiatives such as setting a national low carbon fuel standard and raising automobile energy efficiency by four percent per year. He also supports increasing the renewable share of electricity production to twenty-five percent, and has set a target of sixty billion gallons of biofuels production by 2030. These ideas bear some similarity in spirit to the European Commission's "20-20-20" proposal. Obama & Biden, *supra* note 7. However, these initiatives are likely to face significant practical obstacles. For example, there is a constraint on the amount of land available for large-scale solar installations, which may lead to competition with agricultural land use or destruction of pristine deserts. National Renewable Energy Laboratory, Parabolic Trough FAQs, http://www.nrel.gov/csp/troughnet/faqs.html (last visited Apr. 25, 2009) (on file with the Harvard Environmental Law Review). For a discussion of other renewable energy-related problems, such as siting transmission lines, see Irwin M. Stelzer, *Energy Reality Soon to Intrude on Obama's Enviros*, WASH. EXAMINER, Jan. 23, 2009, *available at* http://www.washingtonexaminer.com/opinion/columns/IrwinStelzer/Energy_reality_soon_to_intrude_on_Obamas_enviros_012309.html.

[115] It may be politically difficult for legislators to remove the tax once the revenue has been allocated to new spending. Therefore, a tax has the advantage of reinforcing the commitment to a national price.

[116] Politicians and policymakers face a difficult tradeoff in trying to design a reasonably stable policy. Because climate change policy will likely have large impacts on society and economies, politicians will want to play a role in crafting and redesigning policies periodically. However, to achieve the kind of policies that yield substantial efficiencies, politicians may need to delegate many of the key decisions on science and economics to technocratic elites.

[117] See *supra* note 94 for a discussion of carbon leakage.

the large economic transfers that would be needed to entice non-participating countries. In my view, pursuing this more limited approach is a price worth paying to begin building some of the needed institutions to address the problem. In particular, we will learn through experience how to better design market-based approaches for reducing greenhouse gases, and there may be the side-benefit of more rapid technological progress that makes an agreement with non-participating countries less costly and more likely in the future.

Some may criticize a proposal for only setting a "modest" price on carbon. When one takes into account the politics, however, this is probably the best course. If the United States were to make deep cuts, it is by no means clear that other countries would follow suit. It is better, in my view, for the United States to make modest reductions in emissions and make its future decisions contingent on the actions taken by other countries to reduce emissions. If other major countries demonstrate through their actions that they will do more, then the United States can respond accordingly.

B. Climate R&D

The second element of my proposal would be a serious reassessment of climate research and development.[118] R&D can help address the climate change issue by stimulating the search for additional new technology to lower costs of emission control, thereby increasing the likely number of participants in a multi-country agreement;[119] improving our ability to adapt to climate change; improving our understanding of the climate issue through better science and economics; increasing our understanding of non-conventional approaches such as geoengineering; and improving our ability to address the problem through the design of better institutions to address the issue (e.g., by learning about how to better use market-based approaches for reducing net emissions, and making better use of carbon sinks such as forests and oceans).

The United States and other countries should move forward with basic and applied R&D because there is the potential for breakthroughs that could help break the political logjam, and also because the economic payoff could be high. A recent study by the National Academy of Sciences of six energy R&D programs found that five of the technological programs produced not only positive net economic benefits, but also environmental and security benefits.[120] An example of a successful initiative is the hybrid vehicle tech-

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[118] *See, e.g.*, Scott Barrett, *A Multitrack Climate Treaty System*, *in* ARCHITECTURES FOR AGREEMENT: ADDRESSING GLOBAL CLIMATE CHANGE IN THE POST-KYOTO WORLD, *supra* note 55. This Part draws on ideas contained in Arrow et al., *supra* note 32.

[119] Some researchers suggest that the costs of carbon abatement with existing technology may be as high as some populations' annual incomes, making actual implementation in lower-income countries very unlikely. *See, e.g.*, Tol, *supra* note 107.

[120] COMM. ON PROSPECTIVE BENEFITS OF U.S. DEP'T OF ENERGY'S ENERGY EFFICIENCY & FOSSIL ENERGY R&D PROGRAMS (PHASE TWO), NAT'L RESEARCH COUNCIL, PROSPECTIVE

nology R&D program, which will cost $567 million through 2012 to research, but is projected to yield $6–7 billion in economic benefits and reduce carbon emissions by 28 million tons and gasoline use by around 200 million barrels.[121]

It is fashionable to call for a large increase in R&D funding.[122] The U.S. federal government currently spends on the order of $3 billion on climate change R&D, depending on what is counted.[123] That amount could increase under an Obama Administration. Such increases should only be made after carefully considering the likely returns from various R&D investments. Not all investments have been great successes. For example, the Synthetic Fuels Corporation established in 1980, which had a production target of 0.5 billion barrels a day, cost billions of federal dollars, only to dissolve in 1986 after predicting that oil prices would soar to $80 to $100 per barrel when they in fact fell to $20 per barrel.[124]

A realistic approach to climate change requires a long-term stable commitment to R&D funding, especially given the long time scale of the problem. Without this commitment, both the public and private sectors will have a bias against long-term or risky but high-potential projects.[125] In R&D, there are likely to be many failures, and there should be. The government is not set up to deal with such failures, but needs to allow and encourage independent agencies to develop a portfolio of investments that encourage an appropriate level of risk taking.[126] That means that ex post R&D "failures" should not be prima facie grounds for reducing funding.[127]

EVALUATION OF APPLIED ENERGY RESEARCH AND DEVELOPMENT AT DOE (PHASE TWO) 6, 123 (2007).

[121] Benefits from hybrid vehicle technology are higher in the case of high oil and gas prices — economic benefits go up to $28 billion and reduce emissions by around 51 million tons of carbon. *Id.* at 6.

[122] *See, e.g.*, Peter Ogden, John Podesta & John Deutch, *A New Strategy to Spur Technology Innovation*, ISSUES IN SCI. & TECH., Winter 2008, at 35.

[123] The U.S. Climate Change Technology Program spent $3.1 billion in the fiscal year of 2007, and has requested $4.4 billion for 2009. Robert C. Marlay, Presentation at the IEA Workshop on Energy Technology Roadmaps: Roadmaps from the U.S. Climate Change Technology Program Strategic Plan (May 15–16, 2008), *available at* http://www.climatetechnology.gov/presentations/CCTPBrief-Marlay-CEQ-19May2008-v2.pdf.

[124] Richard G. Newell, *Issue Brief 9: Climate Technology, Research, Development and Demonstration: Funding Sources, Institutions and Instruments*, *in* ASSESSING U.S. CLIMATE POLICY OPTIONS: A REPORT SUMMARIZING WORK AT RFF AS PART OF THE INTER-INDUSTRY U.S. CLIMATE POLICY FORUM 117, 129 (2007). For a detailed narration of the Synthetic Fuels Corporation's origins and collapse, see THE TECHNOLOGY PORK BARREL (Roger G. Cohen & Linda R. Noll eds., 1991).

[125] *See, e.g.*, Newell, *supra* note 124.

[126] One way to reduce political influence and encourage high-risk R&D ventures is to ask a non-governmental body, such as a university, to allocate funding based on merit. Universities, such as Stanford, now do this in the area of climate change with non-governmental money. The advantage of such a proposal is that it would make it more difficult for politicians to influence the process. The key issue is whether such proposals would be politically feasible, but they at least should be explored.

[127] A 2006 technical review of the Climate Change Technology Program concluded that the Program should allocate more resources to high-risk projects that have prospects of high payoffs in the long term. The review also urged more basic research. *See* MARILYN A.

The United States ought to be considering a wide array of options to promote R&D.[128] In particular, it should recognize that positive incentives alone, such as providing subsidies to renewable energy R&D, are likely to be ineffective and costly to implement compared to negative incentives such as a price on carbon.[129] One investment that governments can make now toward the R&D effort is to enact policies that will increase the supply of workers in these technological and scientific fields, thereby reducing any crowding-out effect on other productive R&D activities.[130]

Carbon dioxide emissions are so pervasive that they present many tempting targets for R&D, but R&D should not concentrate only on carbon dioxide to the exclusion of other GHGs. For example, R&D could also focus on studying and reducing nitrous oxide emissions from fertilizer and biofuel production, which may offset the positive climate impacts of switching from fossil fuels.[131] Limiting all Kyoto GHG emissions could lead to a one-third decline in costs as well as an additional five percent reduction in GHG emissions compared to the case where only CO_2 emissions are limited.[132]

A reasonable near-term strategy for allocating R&D expenditures is to examine where major emissions are likely to originate and identify promising opportunities for reducing them. For example, coal burning is projected to account for forty-four percent of CO_2 emissions from energy use between now and 2030, while oil burning will account for thirty-five to forty percent (natural gas accounts for roughly another twenty percent).[133] This would suggest that some form of low-cost carbon capture and storage ("CCS") is

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BROWN ET AL., OAK RIDGE NAT'L LABORATORY, RESULTS OF A TECHNICAL REVIEW OF THE U.S. CLIMATE CHANGE TECHNOLOGY PROGRAM'S R&D PORTFOLIO 12–13 (2006).

[128] An intriguing policy instrument that has become more popular is offering a prize or award for productive and innovative R&D. This instrument has the advantage that governments pay only for results and not the process, and it may also attract a more diverse range of researchers. Newell, *supra* note 124, at 132.

[129] Carolyn Fischer & Richard G. Newell, *Environmental and Technology Policies for Climate Mitigation*, 55 J. ENVTL. ECON. & MGMT. 142, 160 (2008). Popp shows that carbon taxes are about 8.6 times as effective at recovering welfare lost through market failure as R&D subsidies (with taxes only, gains are $2.31 trillion, while with subsidies only, gains come to $0.27 trillion (2001 dollars)). David Popp, *R&D Subsidies and Climate Policy: Is There a "Free Lunch"?*, 77 CLIMATIC CHANGE 311, 326 (2006).

[130] Popp, *supra* note 129, at 328.

[131] P. J. Crutzen et al., *N_2O Release from Agro-Biofuel Production Negates Global Warming Reduction by Replacing Fossil Fuels*, 8 ATMOSPHERIC CHEMISTRY & PHYSICS 389 (2008).

[132] JOHN M. REILLY, HENRY D. JACOBY & RONALD G. PRINN, PEW CTR. ON GLOBAL CLIMATE CHANGE, MULTI-GAS CONTRIBUTORS TO GLOBAL CLIMATE CHANGE: CLIMATE IMPACTS AND MITIGATION COSTS OF NON-CO_2 GASES (2003). Reducing non-CO_2 emissions is the fourth goal of the U.S. Climate Change Technology Program, which allocates funding to federal agencies, national laboratories, and universities. Marlay, *supra* note 123.

[133] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, INTERNATIONAL ENERGY OUTLOOK 2008, 89 (2008), *available at* http://www.eia.doe.gov/oiaf/ieo/pdf/0484(2008).pdf. In response to recent high oil prices, Europe is set to build fifty new coal-fired plants by 2013. Elisabeth Rosenthal, *Europe Turns Back to Coal, Raising Climate Fears*, N.Y. TIMES, April 23, 2008, at A1.

needed for fossil fuel generating plants, or a competitive source of electric power generation is needed with better emissions characteristics.[134]

There is evidence suggesting that current expenditures on CCS projects may be too low,[135] partly due to the lack of commercial viability in the near term.[136] There are at least two good reasons to continue investing in CCS. First, facilities could benefit from improved efficiency and a fifty percent decrease in total costs from the demonstration phase to the commercial phase.[137] Second, coal, unlike oil, is produced by a large number of countries that are friendly to the United States, and incurs fewer security externalities.[138] Thus, a near-term R&D strategy should consider focusing on cost and safety improvements in CCS technologies.[139]

There is also growing interest in technologies that remove carbon dioxide directly from the atmosphere, such as passing air through sodium hydroxide.[140] While the costs of "vacuuming" carbon dioxide from the atmosphere are currently high, they are comparable to the costs of CCS technologies. Moreover, they have some advantages because they can be located near storage areas.[141] They deserve some public support.

Another potentially promising avenue that should be pursued is making nuclear power cheaper and safer. Nuclear power may be the only off-the-shelf technology that that could compete with fossil fuels in terms of cost. A Massachusetts Institute of Technology ("MIT") cost analysis shows that nuclear power can match fossil energy prices if certain plausible cost improve-

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[134] Additionally, CCS can help to reduce emissions of "black carbon," which is produced by the open burning of solid fuels. The pollutant is not a greenhouse gas but is an important contributor to global warming. *See* Institute for Governance and Sustainable Development, Black Carbon, http://www.igsd.org/blackcarbon/index.php (last visited Apr. 25, 2009) (on file with the Harvard Environmental Law Review).

[135] Current investment in CCS projects is very far below the levels needed to make it a major part of efforts to cut emissions in the power sector. Varun Rai et al., *PESD Carbon Storage Project Database* 2 (Stanford Program on Energy & Dev., Working Paper No. 76, 2008).

[136] Below a price of $55 per ton of carbon, firms are unlikely to voluntarily install CCS capabilities at large industrial facilities. NATALIE TAWIL, CONG. BUDGET OFFICE, THE POTENTIAL FOR CARBON SEQUESTRATION IN THE UNITED STATES 14–15 (Christian Howlett ed., 2007). If carbon prices are higher in the more distant future, coal may still be relatively expensive compared to natural gas, even with ninety percent carbon capture. SERGEY PALTSEV ET AL., MASS. INST. OF TECH. JOINT PROGRAM ON THE SCI. & POLICY OF CLIMATE CHANGE, THE MIT EMISSIONS AND PREDICTION AND POLICY ANALYSIS (EPPA) MODEL: VERSION 4, at 38–39 (2005).

[137] THOMAS NAUCLER ET AL., MCKINSEY & CO., CARBON CAPTURE AND STORAGE: ASSESSING THE ECONOMICS 32–33 (2008). IPCC estimates that costs of carbon capture, the costliest part of CCS, will fall by twenty to thirty percent in the next ten years. IPCC WORKING GROUP III, IPCC SPECIAL REPORT: CARBON DIOXIDE CAPTURE AND STORAGE: SUMMARY FOR POLICYMAKERS 11 (2005).

[138] IRWIN STELZER, ENERGY POLICY: ABANDON HOPE ALL YE WHO ENTER HERE 18 (2008).

[139] More needs to be learned about the environmental consequences of storage. *See, e.g.*, Soren Anderson & Richard Newell, *Prospects for Carbon Capture and Storage Technologies*, 29 ANN. REV. ENV'T RESOURCES 109 (2004).

[140] Frank Zeman, *Energy and Material Balance of CO_2 Capture from Ambient Air*, 41 ENVTL. SCI. TECH. 7558, 7558 (2007).

[141] *Scrubbing the Skies*, ECONOMIST, Mar. 5, 2009.

ments, such as a twenty-five percent decrease in construction costs, are made.[142] Thus, it probably makes sense to consider a large-scale R&D effort to improve nuclear technology.

Besides technical obstacles, nuclear energy faces political opposition. There is now at best a grudging acknowledgement on the part of some politicians that nuclear power should be considered at all. No construction permits for new nuclear power plants have been issued for thirty years,[143] although seventeen new applications since 2007 are currently under review;[144] in contrast, nuclear power capacity in France has grown rapidly during this period and now accounts for seventy-five percent of electricity generation.[145] The public is still very concerned about problems of waste disposal and the proliferation of nuclear weapons.[146] While the issues of waste disposal and weapons proliferation are unlikely to go away in the near future, they can be mitigated through changes in technology and management.[147] In addition to the financial incentives that are currently offered to "first mover" investors through the Energy Policy Act of 2005,[148] the government should signal its willingness to support the expansion of nuclear energy production by resolving the waste disposal problem and other institutional barriers to investment.[149]

Because achieving a worldwide agreement on emissions is likely to be problematic, many countries are likely to turn to adaptation in lieu of mitigation. The U.S. Climate Change Science Program currently spends on the order of $160 million, or about fourteen percent of its budget, examining the sensitivity and adaptability of human and environmental systems.[150] More should be devoted to this area of research, and in addition, more attention

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[142] MIT NUCLEAR ENERGY STUDY ADVISORY COMM., THE FUTURE OF NUCLEAR POWER: AN INTERDISCIPLINARY MIT STUDY 7 (2003). If the United States could halve nuclear power costs, many countries might not only consider adopting this technology, but also willingly submit to international supervision.

[143] Paul L. Joskow, *The Future of Nuclear Power in the United States: Economic and Regulatory Challenges* 1 (MIT Ctr. for Energy & Envtl. Policy Research, Working Paper No. 19, 2006).

[144] ENERGY INFO. ADMIN., U.S. DEP'T OF ENERGY, STATUS OF POTENTIAL NEW COMMERCIAL NUCLEAR REACTORS IN THE UNITED STATES (2009), *available at* http://www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/com_reactors.pdf.

[145] World Nuclear Association, Nuclear Power in France, http://www.world-nuclear.org/info/inf40.html (last visited Apr. 1, 2009) (on file with the Harvard Environmental Law Review).

[146] *See New Harris Poll "Flashback" Finds Half of Americans Favor Building More Nuclear Power Plants*, REUTERS, Oct. 7, 2008, *available at* http://www.reuters.com/article/pressrelease/idus112324+07-oct-2008£w20081007.

[147] MIT researchers recommend focusing R&D efforts on open once-through fuel cycles. Closed fuel cycles are less wasteful in terms of resource use, but are more expensive and face a disadvantage in preventing proliferation of nuclear materials or technologies. MIT NUCLEAR ENERGY STUDY ADVISORY COMM., *supra* note 142, at ix–x.

[148] Energy Policy Act of 2005, 42 U.S.C. § 15801–16524 (2006).

[149] For an excellent analysis of the financial risks associated with investing in nuclear energy and possible policy solutions, see Joskow, *supra* note 143, at 18–26.

[150] SUB-COMM. ON GLOBAL CLIMATE CHANGE, CLIMATE CHANGE SCI. PROGRAM, OUR CHANGING PLANET: THE U.S. CLIMATE CHANGE SCIENCE PROGRAM FOR FISCAL YEAR 2009, at 223 (2009).

needs to be paid to adaptation policy, which has historically underprepared for and overreacted to environmental disasters.[151]

Another possibility is to focus more on geoengineering as a way of hedging against the lack of international mitigation efforts. The political, scientific, and economic dimensions of geoengineering need to be explored more carefully, given the likelihood that one or a small group of countries would embark on this path by itself.[152] There are many types of geoengineering, and research should attempt to reduce key economic and scientific uncertainties and risks associated with different approaches. For example, if the world were to embark on a policy of solar radiation management, accomplished through injecting sulfate aerosol into the atmosphere, then that system would need to be monitored carefully to prevent sudden and rapid temperature increases.[153] We also need to know more about its limitations with regard to ocean acidification and the likelihood that the policy would lead to ozone depletion or other side effects.

Technological breakthroughs are key to encouraging countries, particularly developing countries, to reduce emissions. However, the road may not be easy because the diffusion of such breakthroughs cannot be taken for granted. Adapting new technologies in different areas will require not only substantial investment but also time.

Developing countries that stand to benefit less from emissions control also need to have the incentives and institutional capability to adopt the new technologies that may be made available to them. More research will be needed on ways to induce countries to participate in various agreements. For example, there is a need to work on a credible agreement on preserving or enhancing carbon sinks, and ideally connecting that agreement to one on emissions, so the incentives are aligned appropriately. For example, if technology evolves to the point where carbon dioxide can be removed from the atmosphere at a reasonable cost, such a strategy would need to be given adequate credit. Countries need to experiment with institutions that will be needed to manage a portfolio of solutions for addressing climate change over the longer term.[154]

Climate R&D in many areas will be subject to great political pressures. Even without such pressures, it is difficult to design a reasonable R&D program that will help reduce emissions. A clear danger is that research and

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[151] *See* Robert Repetto, *The Climate Crisis and the Adaptation Myth* (Yale Sch. of Forestry & Envtl. Studies, Working Paper No. 13, 2008). Economists can contribute by improving estimation of these mitigation costs and carefully evaluating the costs and benefits of different strategies for adapting to a changing climate.

[152] Barrett, *supra* note 9; *see also* Lane & Montgomery, *supra* note 41, at 39–40. For an assessment of regulatory issues raised by geoengineering, see David G. Victor, *On the Regulation of Geoengineering*, 24 OXFORD REV. ECON. POL'Y 322 (2008).

[153] NAT'L AERONAUTICAL & SPACE ADMIN., WORKSHOP REPORT ON MANAGING SOLAR RADIATION 13 (Lee Lane et al. eds., 2007).

[154] For an ambitious proposal outlining one possible global agreement on climate change, see Cameron Hepburn & Nicholas Stern, *A New Global Deal on Climate Change*, 24 OXFORD REV. ECON. POL'Y 259 (2008).

development becomes politicized in much the same way that current United States energy policy is politicized (e.g., the support for corn-based ethanol). Avoiding politicization will not be easy, but can be aided with long-term funding from Congress, giving respected agencies such as the National Science Foundation considerable funding authority, and encouraging or providing peer review.

C. The Need for Political Leadership

A well-known problem with climate change is the "free rider" problem, whereby countries try to free ride on the actions of other countries — in this case, investments in greenhouse gas emissions reduction. Yet we already observe some developed countries willing to incur costs in the present even without the participation of key emitters.[155] These actions suggest that countries may be willing to do more than is dictated by narrow self-interest. Thus, while we should not lose sight of the fact that self-interest will likely be a major determinant of behavior,[156] we should not assume that countries will necessarily do what is only best for themselves.

Given this observation, a key element of a solution to the climate problem that has been noticeably absent is political leadership. This may be a strange claim given the willingness of politicians to claim credit for proposed actions on climate change. But I am talking about a different kind of leadership, the kind that was shown by Winston Churchill in World War II. What is needed is a political leader who will level with the nation and the world.

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[155] There is some evidence that average American willingness to pay is substantial. A 2007 MIT study of 1236 online respondents finds that Americans are willing to pay, on average, an additional $21 in higher electricity bills to address global warming. Since the average household emits 7.4 metric tons of CO_2 per year due to electricity use, this implies a willingness-to-pay of $125 per ton of carbon. Thomas E. Curry, Stephen Ansolabehere & Howard Herzog, *A Survey of Public Attitudes Towards Climate Change and Climate Change Mitigation Technologies in the United States: Analyses of 2006 Results* 18 (Mass. Inst. of Tech. Lab. for Energy & the Env't, Working Paper No. 1, 2007); U.S. Envtl. Prot. Agency, Climate Change — Greenhouse Gas Emissions: In the Home, http://www.epa.gov/climatechange/emissions/ind_home.html (last visited Feb. 18, 2009) (on file with the Harvard Environmental Law Review). On the other hand, the 2008 Gallup poll finds that only forty percent of Americans believe that global warming will "pose a serious threat" in their lifetimes, and only thirty-four percent of Americans think that global warming warrants "immediate, drastic action." Frank Newport, Little Increase in Americans' Global Warming Worries, http://www.gallup.com/poll/106660/Little-Increase-Americans-Global-Warming-worries.aspx (last visited Feb. 18, 2009) (on file with the Harvard Environmental Law Review). Victor suggests that public opinion of global warming can be "highly malleable" and is especially sensitive to economic conditions. David G. Victor, Climate Change: Debating America's Policy Options 64 (2004). I think that Victor is correct, and would add that the estimate of willingness to pay is likely to be very sensitive to how the question is framed.

[156] For some suggestions of how specific developing countries could be persuaded to make significant contributions to mitigation efforts, see David G. Victor, *Climate Accession Deals: New Strategies for Taming Growth of Greenhouse Gases in Developing Countries* (Harvard Project on Int'l Climate Agreements, Working Paper No. 08-18, 2008).

Here is an example of what he or she might say (in more colorful prose crafted by a speechwriter):

> "Climate change is a serious problem. We are currently imposing unacceptable costs on future generations. The countries of the world need to respond, and respond quickly. You will be asked to make significant economic sacrifices that reflect the costs being imposed on future generations. Your sacrifice may not benefit you very much, but will very likely benefit future generations.
>
> "We will develop our strategy based on the best science and economics, and not on political correctness. If nuclear technology turns out to be safe and relatively inexpensive, we will use it. If injecting some chemicals in the ocean or the atmosphere will help delay the onset of warming, we will seriously consider that approach if it is thought to be safe and reliable. In short, we will consider using any and all approaches that pass an economic and scientific sniff test."[157]

To be sure, some politicians have made statements like this regarding regulation and climate change,[158] but none has taken what I would call a leadership role, especially while in office. In particular, none has made it clear that the approach will involve sacrifice and could be very costly. Adopting this position would likely entail significant risks, for it is not a message that the public will want to hear. Indeed, this helps to explain why many politicians perpetuate the myth that there is a large "free lunch out there," and that green jobs represent an attractive way to address the problem. Still, I believe a Nixon-goes-to-China strategy could work if tailored carefully and delivered by the right messenger.[159]

Researchers who advise politicians in such roles need to spell out what is needed and why, as well as the risks to the politician, who, of course, will be all too well aware of the downsides. But there is an upside for that unique politician as well. After most of the heroes and villains of World War II have faded from memory, Churchill still stands out for his role in saving the free world.

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[157] For an example of a presidential speech that promotes adaptation, see VICTOR, *supra* note 155, at 76–88.

[158] *See, e.g.*, Tony Blair, Prime Minister of the U.K., Address at the Institute of Public Policy Research: Future Challenges: Living with Risk (May 26, 2005) (transcript available at http://www.number10.gov.uk/Page7561).

[159] I believe that President Obama faces a unique challenge and opportunity here. The challenge will be to avoid having climate policy (and energy policy more generally) get bogged down in traditional pork barrel politics. The opportunity for the President is to introduce a new, innovative approach to the climate problem based on sound economics and game theory.

V. Conclusions and Future Research

Economist William Nordhaus once observed that "the greenhouse effect is the granddaddy of public goods problems."[160] As with most things, he is correct. This Paper has tried to elaborate on one aspect of that problem that has received insufficient attention from policymakers and academics: the difficult politics of the situation.

I have argued that a global environmental agreement to curtail climate emissions, no matter how badly many might want one, is not in our near-term future. That is an "inconvenient truth" that we ignore at our own peril. And it is just as inconvenient, from my perspective, as the very important truth for which Mr. Gore received the Nobel Prize, which is that climate change should be taken seriously.

The politics of climate change has some important implications. First, as noted, climate change policy is not going to be anywhere near economically efficient. Indeed, we cannot rule out the possibility that it may not make sense to reduce emissions now at a national level, though that is *not* my preferred option because I believe lowering GHG emissions now by relying on taxes or cap-and-trade could help stimulate needed innovation, which may reduce the reluctance of some developing nations to act.

Second, serious thought needs to be given to increasing the probability of reaching a successful agreement over time, *if* that is possible. I have argued, for example, that it makes sense for the United States to put a modest price on carbon at this time, but it does not make sense for the United States to make steep reductions in greenhouse gas emissions in the near term. Deep cuts only make sense if most or all of the world's countries are moving together toward a goal of reducing global emissions.

We should not lose sight of the fact that many countries will not find it in their narrow interests to participate in an agreement in the near term without receiving some kind of subsidies. Key levers for improving participation over time include an increasing world standard of living (think free trade) and lowering the costs of emissions reduction over time through judicious use of R&D and pricing of greenhouse gas emissions. In addition, public opinion could exert a great influence.

Third, because the mitigation option may not be effective or effective enough, we need to be carefully exploring other options. For example, it may be the case that adaptation is likely to be more efficient than reducing emissions, because adaptation will not typically require global cooperation. If that is the case, we may want to do more adaptation than a first-best solution would suggest and less mitigation. The point is we need to think hard about designing new policy solutions and how those solutions will actually be implemented. These include both geoengineering and adaptation.

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[160] William D. Nordhaus, *Reflections on the Economics of Climate Change*, J. Econ. Persp., Fall 1993, at 11, 18.

Fourth, because energy politics is omnipresent, economists should learn to deal with it, or at least deal with it better. That means recognizing the myriad shortcomings in their models and trying to apply them more sensibly. Inefficient payroll taxes, for example, will not magically disappear just because an economist shows the value of substituting carbon taxes for payroll taxes. While such demonstrations can be useful in highlighting the theoretical potential of different kinds of policies, they also have severe limitations because of their simplifying assumptions.[161]

Climate change is a very important issue, particularly if the worst predictions turn out to be right and things actually do spin out of control.[162] It deserves to be debated thoughtfully in the academy and by decision makers. It also deserves a reasoned response that keeps Bismarck's insight clearly in mind: "Politics is the art of the possible."[163] We may want to try to stretch the envelope of what is possible, but we should not harbor any illusions that politics will disappear in the brave new world.

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[161] Economic models that identify the welfare advantages associated with a first-best solution can be useful for at least three reasons. First, they can demonstrate potential welfare gains over the status quo; second, in cases where such gains are small, they may suggest that such gains may not be worth fighting over; third, in cases where such gains are large, such modeling efforts can help nudge policy in the direction of achieving some of those gains. Still, it would be useful for economists to be clearer about some of the limitations of their modeling as it applies to policy. These include highlighting the importance of a host of simplifying assumptions related to the response of firms and government and estimations of the costs and benefits of climate change.

[162] There are competing scientific views on the timeline of worst-case scenarios. One of the most widely cited fears, the disappearance of the Greenland ice sheet leading to a rapid rise in sea levels, is unlikely to occur within the century. *See* FOURTH ASSESSMENT REPORT SYNTHESIS, *supra* note 13, at 47. However, many other damages such as weather pattern changes are likely to occur before then, and the effects are likely to be long-lasting. Solomon et al., *supra* note 29.

[163] YALE BOOK OF QUOTATIONS 86 (Fred R. Shapiro ed., 2006) (remark by Otto von Bismarck to Meyer von Waldeck).