US Climate Policy Post-Kyoto:
Scientific Underpinnings, Policy History, and the Path Ahead

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I. Introduction

The problem of disruption of global climate by human-produced greenhouse gases[1] (GHG) in the atmosphere will likely come to be understood over the next decade or so, by publics and policy makers alike, as the most dangerous and intractable of all the environmental problems caused by human activity.

- It is the most dangerous because climate is the "envelope" within which all other environmental conditions and processes operate, and distortions of this envelope of the magnitude that are in prospect are likely to so disrupt these conditions and processes as to impact adversely the productivity of farms, forests, and fisheries; the geography of disease; the livability of our cities in summer; the damages to be expected from storms, floods, and wildfires; and much more.

- It is the most intractable because the dominant cause of the disruption – emission of carbon dioxide from fossil-fuel combustion – arises from the process that currently supplies nearly 80 percent of civilization's energy, and because the technologies involved cannot be quickly or inexpensively changed or replaced in ways that would eliminate the problem.

Past and current US practices and policies relating to climate change and energy are not commensurate with these realities. After brief summaries of current understanding of the magnitude of the climate-energy challenge and the evolution of US policy through the conclusion of the 1997 Kyoto Conference, this paper addresses developments in US climate and energy policies since Kyoto and offers a few observations on the way forward.

II. State of Knowledge About Climate Science

Among those with the training and knowledge to penetrate the relevant scientific literatures, the debate about whether global climate is now being measurably changed by human-produced greenhouse-gases is essentially over. Few of the climate-change "skeptics" who appear regularly in the op-ed pages of *The Washington Times* and *The Wall Street Journal* have any scientific credibility at all. The most distinguished scientist from the camp of the more-or-less skeptical – meteorology professor Richard Lindzen of MIT – signed without dissent the 2001 National Academy of Sciences report (which had been requested by President George W. Bush) affirming the fundamental soundness of the Third Assessment of the Intergovernmental Panel on Climate Change (IPCC) and declaring in its opening sentence that

[1] A glossary with definitions of terms, institutions, and policy mechanisms is provided as Appendix A.

"Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise."[2]

Significant uncertainties remain, and debates about them persist, but they are not about whether climate is changing or whether greenhouse-gas emissions from human activities are responsible for a significant part of this, but about (a) the precise magnitude of the climatic changes to be expected by 2030, 2050, or 2100 if civilization does not change course; (b) the character, geographic distribution, and timing of the damages to human well-being to be expected from these changes, and the probability that much bigger than "expected" damages will result from pushing the climate over a threshold or "tipping point"; (c) the feasibility, costs, and leverage of various potential remedies; and (d) the appropriate character and timing of national and international policies to reduce the risks from anthropogenic disruption of global climate.

III. Requirement for Addressing Carbon Dioxide Emissions

In principle, there are four kinds of measures by which society can try to reduce the damages from GHG-induced climate change: (a) reducing the emissions of GHG from human activities; (b) removing GHG from the atmosphere by enhancing natural "sinks" or creating artificial ones; (c) "geotechnical engineering" to offset the heat-trapping effects of increased GHG concentrations (such as by lofting sunlight-reflecting .particles into Earth orbit); and (d) adapting to the changes in climate that ensue (for example, by altering agricultural practices, constructing water projects to alleviate floods and droughts and dikes to deal with rising sea level, and so on).

In practice, adaptation is already going on in relation to the changes in climate that are already being experienced, and because further climate change is unavoidable even if civilization starts to act now to minimize it, more adaptation will certainly be required. But a strategy of pure adaptation and no abatement would be foolhardy: if the changes in climate become too large, adaptation will become very expensive and nonetheless ineffective against many of the impacts. Within the sub-categories of abatement, "geotechnical engineering" deserves more study but carries its own risks and cannot now be assured to make a significant contribution. Removing GHG from the atmosphere is certainly practical in the case of carbon dioxide (CO2) by growing more trees, but it is unlikely that more than 20-25% of the CO2 accumulation expected in the current century could be taken up in this way; gaining more by fertilizing the oceans may be possible but is laden with uncertainties and dangers; and technological approaches to GHG removal are likely to be quite costly. Reducing emissions is therefore essential.

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[2] See Appendix B, which assembles key quotes from the National Academy report and from the climate-science section of the IPCC Third Assessment.

On which emissions should we focus? Carbon dioxide (CO2) is not the only anthropogenic greenhouse gas whose growing concentration in the atmosphere has been contributing to global climate change. Others include methane, halocarbons, tropospheric ozone, and nitrous oxide. Emissions of black soot also contribute to global warming, partly offsetting the cooling effects of other kinds of particulate matter in the atmosphere. But the warming effect of the anthropogenic CO2 increases up to the present is larger than that of all of the other anthropogenic warming influences combined; and under anything resembling "business as usual" growth of economic activity and fossil-fuel use, CO2's importance relative to other influences on global climate will increase dramatically through the 21st century.[3] While it is certainly worthwhile to try to limit emissions of non-CO2 GHG and black soot, as many analysts have suggested, CO2 is the 800-pound gorilla in the climate-change problem, and any sensible strategy must aim for large reductions in the emissions of this gas.

IV. By How Much Should Carbon Emissions Be Reduced?

Global emissions of carbon from fossil-fuel burning amounted in 2000 to about 6.4 billion metric tons of carbon contained in CO2 (expressed as GtC, for gigatons of carbon), of which US emissions of 1.6 GtC accounted for 25%. The fossil fuels responsible for these emissions constituted 78% of world energy supply and 85% of US energy supply.[4] Global emissions of carbon from tropical deforestation amounted to perhaps 1.5 GtC annually and those from cement production another 0.2 GtC. Better management may enable the emissions from deforestation to decline, and the expected growth in the modest contribution from cement is not of great consequence. The essence of the CO2 problem is the fossil fuels, from which global emissions under the "middle of the road" IS92a scenario of the IPCC would reach 14 GtC per year by 2050 and over 20 GtC per year by 2100.

The size of the CO2-emissions-reduction challenge becomes apparent when one recognizes that stabilizing the atmospheric concentration of CO2 requires not just leveling off emissions at a level not too much higher than today's but subsequently bringing emissions down, over a period of many decades, to a fraction of today's. For example, if one wished to stabilize the atmospheric concentration of CO2 at 550 parts per million by volume (ppmv) – that is, at about twice the pre-industrial concentration – and if one wanted to avoid stabilization trajectories that place too much of the burden of reductions in the early

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[3] The role of CO2 compared to other influences on climate is described in quantitative terms in Appendix C.

[4] World use of primary energy forms in 2000 amounted to 450 exajoules (1 EJ = 10^{18} J = 0.95 quadrillion Btu = 22 million tonnes of oil). Of this total, 35% came from oil, 23% from coal, and 20% from natural gas. Nonfossil contributions were principally 13% from biomass fuels (fuelwood, charcoal, crop wastes, dung, and biomass-derived alcohol), 6% from nuclear energy, and 2% from hydropower. Renewable sources other than biomass and hydropower – notably geothermal, wind, and solar energy – contributed altogether less than 0.5 percent. In the United States, the 2000 primary energy supply of 105 EJ was derived 38% from oil, 24% each from coal and natural gas, 7.7% from nuclear energy, 3.7% from biomass, 1% from hydropower, and 0.4% from other renewables.

decades of the century, as well as avoiding those that involve extremely steep declines later, then one would want to level off emissions at about 11 GtC around the year 2035 (which is not so far above the total emissions of 8 GtC/year from fossil-fuel combustion, cement manufacture, and deforestation combined in 2000) and then begin gradually to decline, falling to about 6-7 GtC/year by 2100 and to 3-4 GtC/year by 2200.[5] This particular target for stabilization of the atmospheric CO2 concentration, 550 ppmv, is an interesting one to consider further, in part because studies of the climate-change impacts likely to ensue at this concentration suggest that going further would be imprudent in the extreme, and in part because studies of the rate of transformation of the world's energy-supply system needed to stabilize at any lower CO2 concentration than 550 ppmv makes this seem very difficult to achieve.

It is an easy matter to calculate, under some simplifying assumptions, how much the carbon-free part of world energy supply would need to be expanded in the 21st century in order to get on and stay on a not-too-early/not-too-late trajectory for stabilizing CO2 at 550 ppmv.[6] Assuming "middle of the road" economic growth and continuation of the recent 1%/year world-average rate of reduction of the energy intensity of economic activity, the carbon-free contribution would need to increase 6-fold (to about 600 exajoules) by 2050 and 15-fold (to about 1500 exajoules) by 2100 if the world were on the indicated 550-ppmv-stabilization trajectory. (In other words, the world would need to be obtaining from carbon-free sources by 2100 more than three times as much as energy as it was using altogether in 2000.) Only if the historical world-average rate of energy-intensity reduction can be doubled to 2 percent per year over the whole world and the whole century -- thus halving energy intensity of global economic activity every 35 years – can the requirement for carbon-free energy supply be held to a "mere" tripling in the 21st century. As will be seen in what follows, there is as yet little sign of the sorts of policies and commitments that could yield the needed energy-intensity reductions and carbon-free-energy increases in any combination consistent with stabilizing atmospheric CO2 at 550 ppmv.

V. US and World Climate Policy Through the Kyoto Conference

For practical purposes, climate policy *per se* -- as opposed to (i) policies to support research on climate change and (ii) energy policies that incidentally affect GHG emissions -- began with the United Nations Framework Convention on Climate Change (UNFCCC, see Appendix A). This convention was

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5 An up-to-date and accessible treatment of this complicated matter is T. M. L. Wigley, "Stabilization of Greenhouse-Gas Concentrations", in *U.S. Policy on Climate Change: What Next?*, Aspen Institute, 2002, http://www.aspeninstitute.org/aspeninstitute/files/Img/pdf/WigleyEEEClimate.pdf

6 The carbon-free options are (a) biomass, hydropower, wind, photovoltaics, and other renewable energy sources; (b) nuclear energy (currently nuclear fission and perhaps, after mid-century, nuclear fusion); and (c) advanced fossil-fuel technologies that can capture the carbon and sequester it, rather than releasing it to the atmosphere. In 2000, renewables and nuclear energy – options (a) and (b) -- were supplying about 100 exajoules per year between them, out of 450 exajoules per year total world energy supply. Option (c) was not – and is not – yet operational The calculation is provided in Appendix D.

signed by President George H. W. Bush and many other world leaders at the 1992 "Earth Summit" in Rio de Janeiro and subsequently ratified by the United States Senate and by the governments of 187 other nations. As a Senate-ratified international treaty, the UNFCC became – and remains – the "law of the land" in the United States, but rather little notice was taken of this. Consider the following key elements of the Convention, quoted here verbatim:

> The Parties should protect the climate system for the benefit of present and future generations of humankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities. <u>Accordingly, the developed country Parties should take the lead in combating climate change and the adverse effects thereof.</u> (Article 3, Section 1, emphasis added)
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> The developed country Parties and other parties included in Annex I commit themselves specifically to… (a)…adopt national policies and take corresponding measures on the mitigation of climate change, by limiting [their] anthropogenic emissions of greenhouse gases and protecting and enhancing [their] greenhouse gas sinks and reservoirs…with the aim of returning individually or jointly to their 1990 levels these anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol. (Article IV, Sections 2.a and 2.b).

In the United States and in most other countries, not much was done initially to take these provisions seriously: we and others started to publish inventories of our GHG emissions and increased our expenditures on climate-science research; but expenditures on energy-technology research and development fell in all of the G-7 countries except Japan in the period 1992 to 1997; and the "non-binding" character of the target of returning GHG emissions to their 1990 levels by the year 2000 was taken as license to more or less ignore the UNFCC's mandate to "adopt national policies and take corresponding measures on the mitigation of climate change."[7]

The 3rd Conference of the Parties (COP) to the UNFCC scheduled for December 1997 in Kyoto was intended to address this deficiency by adopting legally binding emissions targets for the post-2000 period, as well as mechanisms for achieving them. (The necessity of this had been agreed, following a strong push from US Undersecretary of State Timothy Wirth, at the 2nd COP in Geneva in mid-1996.) In a series of international workshops following the Geneva decision and leading up to Kyoto, representatives of the world's governments struggled vigorously with the dilemmas of reconciling emissions targets with economic aspirations, developing emissions-trading approaches that would increase the efficiency of reductions without too badly bruising equity concerns, and finding a way to credit the enhancement of "sinks" for GHGs despite the inability of the existing science to quantify convincingly what sink-enhancement would amount to. Whether and how the less-developed countries

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[7] The United Kingdom, Germany, and Russia were on track to meet the year-2000 emissions target, but not for reasons of climate policy. The UK had already decided to drastically shrink its coal industry because of its windfall discoveries of North Sea natural gas (which emits only 60% as much CO2 per unit of primary energy as coal does and only 40% as much per kilowatt-hour of electricity generated). Newly re-united Germany was in the process of shutting down the highly inefficient coal-burning industries in the East German sector. And Russia's economic implosion following the end of the Cold War ensured far lower energy use and, thus, far lower GHG emissions than would have been expected on a normal growth trajectory.

would be constrained by what was to be agreed at Kyoto remained uncertain and contentious throughout the run-up to the meeting.

Despite the efforts of Undersecretary Wirth and the well known convictions of Vice President Gore on the importance of the climate-change issue, there had been little visible leadership from the White House on either climate policy or energy policy during the first Clinton term. A missive to Clinton in December 1996 from his President's Committee of Advisors on Science and Technology (PCAST), however, calling attention to the magnitude and urgency of the energy-climate challenge, led him to request from PCAST a comprehensive review of the adequacy of US energy R&D strategy to address the challenges of the 21st century (including but not limited to climate change), due in fall 1997 in time to influence the Administration's FY2001 budget request and its preparations for the Kyoto Conference.

This PCAST study (which I chaired) concluded that the US energy R&D effort was "not commensurate in scope and scale with the energy challenges and opportunities that the twenty-first century will present" and that the "inadequacy…is particularly acute in relation to the challenge of responding prudently and cost-effectively to the risk of global climatic change from society's greenhouse gas emissions, of which the most important is carbon dioxide from the combustion of fossil fuels." The study recommended that Federal energy-technology R&D be increased from its FY1997 and FY1998 level of $1.3 billion per year to $1.8 billion in FY1999, ramping up to $2.4 billion by FY2003; and it recommended specific allocations of the increases to maximize their leverage against both climate change and US overdependence on imported oil.[8] Of the $500 million increment recommended by PCAST for FY1999, the administration asked for about two-thirds in its budget request (under the heading of the "Climate Change Technologies Initiative"), and the Congress appropriated about 60 percent of the increment requested, leading to an increase of $200 million in US energy-technology R&D for that year. Details of this and subsequent administration requests and Congressional appropriations, compared to the PCAST recommendations, are provided in Appendix E.

In parallel with the preparation of the PCAST report, President Clinton initiated in mid-1997 an intensive process of briefings, workshops, conferences, and Cabinet- and sub-cabinet-level discussions to shape the climate policy that the United States would carry into the Kyoto Conference. This process culminated in President Clinton's speech at the National Geographic Society on October 23, 1997, which outlined his climate package. The basis of his policy, he said, was recognition that (i) corrective action is

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[8] The 1995, 1997, and 1999 PCAST energy studies and their interaction with other aspects of the Clinton administration's energy and climate policies are discussed in detail in "The PCAST Energy Studies: Toward a National Consensus on Energy Research, Development, Demonstration, and Deployment Policy", John P. Holdren and Samuel F. Baldwin, *Annual Review of Energy and Environment*, Vol. 26, pp 391-434, 2001: http://bcsia.ksg.harvard.edu/BCSIA_content/documents/AREE_HoldrenBaldwin01.pdf.

necessary, (ii) emissions reductions are the key to success, (iii) market-based approaches to achieving this are preferable to command-and-control, (iv) developing countries must participate, and (v) the climate-change challenge is an economic opportunity, not just a burden. He indicated that the emissions target the United States would seek for the industrialized countries at Kyoto was a return to 1990 emissions levels in the time period 2008-2012. As measures to achieve these reductions in the United States, he proposed $2.4 billion in increments to energy R&D over the period FY1999-2003 (the five-year version of the CCTI); a package of $3.6 billion in tax incentives over the same period (for, e.g., installation of energy-efficient equipment in residential and commercial buildings, purchase of high-efficiency vehicles, investment in combined-heat-and-power projects and in electricity generation from biomass and wind, and recycling of halocarbons); and some additional incentives for "voluntary" industry action. Only starting in 2008, under the Clinton plan, would there be binding emissions caps, implemented through emissions permits that would be tradable domestically and internationally.

All this was against a backdrop of Europe's and Japan's arguing loudly for more stringent emissions targets (from 5 to 15 percent below 1990 levels by 2010) – accompanied by US suspicions that our allies knew they had no way to achieve such targets, but were counting on the United States to reject them and take the blame – and the US Senate's having passed overwhelmingly, in June 1997, a "Sense of the Senate" resolution indicating that the United States should not be a party to any protocol negotiated at Kyoto or thereafter that would "mandate new commitments to limit or reduce greenhouse gas emissions for the Annex I Parties, unless the protocol or other agreement also mandates new specific scheduled commitments to limit or reduce greenhouse gas emissions for the Developing Country Parties within the same compliance period."

In the actual negotiations in Kyoto, Vice President Gore agreed on behalf of the administration to an emissions target lower than proposed by the President in October – namely, a 7 percent cut from 1990 levels by the 2008-2012 "commitment period" – in the context of industrialized-country commitments mostly in the range of 5 to 8 percent below 1990 levels.[9] Under the Protocol, these commitments are stipulated to be "binding", but the means by which this would be enforced – and shortfalls penalized – was left to future negotiations. Despite some progress at subsequent Conferences of the Parties, the procedures and ground-rules for enforcement of compliance are still not entirely clear today. The Protocol allows for credit for enhancing "sinks" of GHG, but exactly how these are to be measured and credited is also still not entirely worked out. Nor are all of the details of the Protocol's "Clean Development Mechanism" (by which industrialized countries get emissions-reduction credit by

[9] Russia's 2008-2012 target was to be at the 1990 emissions level, however, and Australia managed to negotiate a target of 10% <u>above</u> its 1990 emissions. A further complication is that the 15 European Union members were allowed, under a so-called "bubble" provision, to redistribute their emissions allocations within the total applying to all fifteen.

supporting qualifying projects in developing countries) and international emissions-trading prescriptions entirely worked out. Notwithstanding the exhortation of the US Senate and considerable negotiating efforts in this direction, moreover, the Kyoto Protocol contains no requirement for developing countries to reduce their GHG emissions (or enhance GHG sinks), and indeed it contains no mechanism for these countries to adopt such commitments voluntarily.

VI. US Climate Policy Post-Kyoto

The ink was not dry on the some 160 signatures on the document before it came under fire from almost every direction – for demanding too little, for demanding too much, for focusing too much on targets and timetables and too little on mechanisms for moving in the right direction, for imposing no obligations on developing countries, and for leaving so many of the details to be worked out in the future. It is fair to say that the conventional wisdom now regards the Kyoto Protocol as requiring both too much (in the short term) and too little (in the long term), inasmuch as (i) its goals for 2008-2012 would be difficult to achieve at acceptable costs even if enlightened policies for getting there were already in place in most industrialized countries (which they are not) and (ii) such early reductions would not even be necessary if one would be content to stabilize atmospheric CO2 at 550 ppmv, but much larger reductions would be required over the longer term to meet this goal -- and the Kyoto document specifies no targets at all for the longer term except to say that these will need to be addressed at some time in the future.

Notwithstanding these real and perceived shortcomings, there has been strong interest in much of the world in moving ahead with ratification and implementation of the Kyoto Protocol, on the grounds that it is "the only game in town" – the only tangible expression, beyond the too vague UNFCC, of the world's collective determination to fashion a cooperative framework for addressing what most consider a compelling problem – and on the grounds that the Protocol's defects could be adequately addressed by adjustments to be made going forward. The Clinton administration, despite obvious sympathy for this position, chose not to submit the Protocol for Senate approval before leaving office, presumably because defeat in this period seemed a certainty (not least because of the Protocol's manifest failure to comply with the Senate's requirement for developing-country obligations in the same compliance period as for industrialized nations). It may be supposed that the administration hoped that a Gore presidency and a Democratic Senate would yield a better outcome after the 2000 elections.[10]

[10] President Clinton clearly recognized that bringing the developing countries into a framework of emissions reductions would likely be key to future success with the Senate no matter what its composition, and he asked PCAST to follow up its 1997 study with a new one focused on how to enhance US cooperation with developing countries on advanced energy technologies – the most obvious "carrot" to bring developing countries on board. That PCAST study (which again I had the privilege of chairing) issued its report in June 1999, calling for an immediate doubling of the previous $250 million per year level of Federal support for international cooperation on energy-technology innovation, with a tripling by FY2005. The President requested an increment of $100 million in his FY2001 budget under the title of the "International Clean Energy Initiative", but the Congress passed only $8.5 million of this. See Holdren and Baldwin, cited above at Note 8.

Candidate George W. Bush promised to regulate emissions of CO2 (from electric power plants, at least), but as President he quickly backed away from this commitment. At the very beginning of his term, he asked the National Academy of Sciences to give him an assessment of the validity of the findings of the IPCC, seemingly looking for some "wiggle room" on the science; he got the assessment, but not the wiggle room (see Appendix B). In the meantime, before the NAS report was completed, President Bush let it be known in March 2001 that the United States would not be ratifying the Kyoto Protocol because implementing it "would harm the US economy." The May 2001 report of the National Energy Policy Development group headed by Vice President Cheney offered only a few sentences about the climate-change issue, pointing to the decline in the amount of carbon emitted per dollar of GDP in the United States in the 1990s, cushioning an allusion to the seriousness of the problem by referring to the need for more study, and offering no recommendations directly linked to the climate issue.

In February 2002, nearly a year after renouncing the Kyoto Protocol, the Bush administration announced the climate-policy package it was offering as an alternative. The Bush program (for which the White House Fact Sheet is provided in Appendix F) proposes a goal of reducing the greenhouse-gas intensity of the US economy by 18% in the period 2002-2012, to be achieved mainly through an improved GHG registry, tax credits for deploying low-emission energy technologies, other incentives for voluntary emissions reductions, and increased R&D on clean vehicles and carbon sequestration. Federal energy R&D under the Bush program so far is up in a few respects, about level overall, and well below the Clinton PCAST recommendations (Appendix E). The tax credits in the Bush plan, amounting to $555 million in the first year and $4.6 billion over five years, are similar overall to those offered previously in the Clinton package. The Bush plan also proposed increased US participation in international cooperation to develop and deploy low-emission energy technologies, along some of the lines proposed in the 1999 PCAST report. Progress would be reviewed in 2012 (a date four years beyond the end of a second Bush term, should he win re-election), with consideration of "a broad market-based program" – presumably meaning a tradable-permit system – if "we are not on track toward meeting our goal, and sound science justifies further policy action."

The Bush plan's basing the goal on the carbon intensity of economic activity rather than on the absolute value of emissions has considerable merit, especially as a formula having some hope of eventually attracting developing-country participation. The administration's arithmetic could easily mislead, however, inasmuch as the "target" performance for United States in the decade 2002-2012 is no better than US "business as usual" performance in the decade 1990-2000. And the White House Fact Sheet contention that "the goal is comparable to the average progress that nations participating in the Kyoto Protocol are required to achieve" is nonsense: by the administration's own arithmetic, meeting its 2012 target would leave US GHG emissions in that year some 30% higher than in 1990, whereas complying with Kyoto would require cuts of 5-8% from the 1990 levels for most industrial countries. (See Appendix G.)

VII. The Way Forward

Although the refusal of the United States to ratify the Kyoto Protocol was widely thought at first to have doomed the agreement, it seems now to be about to enter into force without the United States. The requirement for this is that 55 countries must ratify, including Annex I countries accounting for 55% of the 1990 emissions of that group. As this is written in May 2003, the number of ratifications has reached 108, and the 31 of these from Annex I countries account for 43.9% of 1990 Annex I emissions. Ratification by Russia, which is expected, would bring the Protocol into force. The adjustments that have been made to the Protocol to gain such widespread agreement to it will almost certainly reduce the percentage reductions of emissions achieved under it by the participating countries, but that does not vitiate the awkwardness for the United States (and the rest of the world) of such a treaty going ahead without the largest emitter on the planet as a member. What benefits or difficulties this strained and asymmetric situation may pose for US industries, trade balance, and stature in the world (among other factors) remain to be understood...or perhaps not understood, just experienced.

In the meantime, a substantial amount of effort toward reducing GHG emissions in the United States is going forward even in the absence of strong direction from the Federal government. State governments, cities, and corporations in considerable numbers have announced targets for reducing their GHG emissions – in some cases more stringent than those of the Kyoto Protocol – and many are taking concrete steps to achieve them.[11] Still, there are strong reasons for believing that voluntarism will not be enough. As indicated earlier in this paper, the magnitude of the deflection required from "business as usual" is likely to be immense, and targets in the absence of consistent, powerful, across-the-board mechanisms to get us there will not do the job. Neither will modest increases in energy R&D and in international cooperation on energy technology. I believe that we need a doubling or tripling of US Federal support for research, development, and demonstration; a tripling or quadrupling of US assistance on low-emission energy technologies to developing countries; a prompt closing of the loophole for light trucks and SUVs in the US CAFÉ standards, followed by ramping up the fleet-average mileage requirement to 40 mpg by 2015; and, most important but also most difficult to achieve, either a gradually escalating carbon tax or a gradually tightening emissions cap implemented through tradable permits. I also believe that these measures are as likely to help as to harm the US economy, even before counting the climate damages averted. I look forward to discussing these issues further at our meeting in Rome.

[11] See, e.g., Robert W. Kates and Thomas J. Wilbanks, "Making the Global Local: Responding to Climate Change from the Ground Up", *Environment*, April 2003, pp 12-23, and Pew Center on Global Climate Change, "Climate Change Activities in the United States", http://www.pewclimate.org/projects/us_activities.pdf.

Appendix A. A Glossary of Terms in International Climate Policy

Annex I Parties: This term from the UN Framework Convention on Climate Change (UNFCCC C see below) refers to the developed (industrialized) countries, consisting of the OECD plus the countries of Eastern Europe and some of those of the former Soviet Union (Russia, Ukraine, Belarus, and the three Baltic states).

Berlin Mandate: This emerged from the 1st Conference of the Parties (COP) to the UNFCCC (Berlin, March 1995) and focused on the need to take appropriate action to reinforce the commitments in Article 4 of the UNFCCC (see below) with Aquantified limitation and reduction@ objectives for Annex I countries in the post-2000 period. The mandate did not call for new commitments for developing country parties but only for enhanced efforts at implementing the existing commitments relating to these countries in Article 4.

Clean Development Mechanism (CDM): Defined in Article 12 of the Kyoto Protocol (see below), the CDM is an approach to Joint Implementation that allows developed country parties to obtain emissions reduction credit by supporting projects in developing countries that contribute to sustainable development and reduce greenhouse gas emissions below what they would otherwise be. Emissions reductions achieved by CDM projects in the period 2000-2007 could be credited against reduction commitments for the Afirst commitment period@ (2008-2012). Many details remain to be worked out.

Emissions Trading: This concept involves a market in Aemissions permits@ or Aemission reduction credits@, wherein countries that are meeting their limits with room to spare can sell the emissions permits or credits they don=t need to other countries for whom, on the margin, buying such permits or credits is cheaper than meeting their own limits domestically. A version of this approach, described as trading among Annex I parties of Aemission reduction units resulting from projects aimed at reducing anthropogenic emissions by sources or enhancing anthropogenic removals by sinks of greenhouse gases in any sector of the economy@, is embodied in Article 6 of the Kyoto Protocol (see below).

Global Environment Facility (GEF): The GEF is an entity organized under the auspices of the World Bank as the financing mechanism to address global environmental issues by paying the Aagreed full incremental costs@ of measures to address these issues taken by the developing countries. It was designated as the interim financial mechanism of the UNFCCC by the Conference of the Parties.

Greenhouse Gases (GHGs): GHGs are transparent to incoming solar radiation in the visible wavelengths and partly opaque to outgoing terrestrial radiation in the infrared wavelengths. By absorbing and re-radiating back to Earth part of the outgoing terrestrial radiation, they make the surface of the Earth warmer than it would otherwise be. The anthropogenic GHGs regulated by the UNFCCC and its Kyoto Protocol are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs C containing only hydrogen, fluorine, and carbon), perfluorocarbons (PFCs C containing only carbon and fluorine), and sulphur hexafluoride (SF_6). Chlorofluorocarbons (CFCs) are also important anthropogenic GHGs, but they are not regulated by the Kyoto Protocol because they were already restricted under the Montreal Protocol of 1987 (see below). Water vapor is the GHG that accounts for the largest part of the *natural* greenhouse effect; its concentration globally is not significantly influenced by emissions of water vapor from human activities but may be substantially increased by warming caused by anthropogenic increases in the other greenhouse gases (the Awater-vapor feedback@).

Intergovernmental Panel on Climate Change (IPCC): The IPCC was established jointly by the World Meteorological Organization and the UN Environment Programme in 1988 with a mandate to A(i) assess available scientific information on climate change, (ii) assess the environmental and socioeconomic impacts of climate change, and (iii) formulate response strategies. The First Assessment Report of the IPCC, completed August 1990, served as the main technical input to the negotiation of the UNFCCC in Rio in 1992. The IPCC=s Second Assessment Report, completed in 1995 and published in 1996, served a similar function in relation to the development of the Protocol to the UNFCCC in Kyoto in 1997. The Third Assessment Report was published in 2001 and the fourth is due in 2005-6. Some thousands of scientists and other specialists from more than 40 countries have served as authors and reviewers of the IPCC's reports.

Joint Implementation (JI): Introduced in the UNFCCC, JI is a mechanism in which countries party to the Convention can meet part of their commitments to reduce GHG emissions by means of emissions credits gained by arranging projects that reduce emissions in other (Ahost@) countries. The idea is to offer investor countries or firms cheaper GHG-reduction options than they could arrange domestically, while providing host countries advanced energy-supply, energy-efficiency, and forest-management projects on favorable terms.

Kyoto Conference: The 3rd Conference of the Parties (denoted COP3) to the UNFCCC was held in Kyoto 1-10 December 1997 with the aim of carrying out the Berlin Mandate. It led to the Kyoto Protocol (see below), specifying targets and timetables for developed-country GHG reductions in the post-2000 time period.

Kyoto Protocol: Commits Annex I parties (with the exception of Australia, Iceland, New Zealand, Norway, Russia, and Ukraine) to reduce their overall emissions of GHG by 5-8 percent below 1990 levels (1995 levels for the HFCs, PFCs, and SF_6) in the Acommitment period@ 2008 to 2012 and to make Ademonstrable progress@ toward achieving these commitments by 2005. Overall emissions are to be computed on a Anet@ basis, accounting for afforestation, reforestation, and deforestation as well as emissions from energy supply and other industrial activities. The most substantive parts of the Protocol=s text are Articles 3 (quantitative goals and baselines), 4 (possibility of agreements on joint fulfillment of commitments, 5 (national systems of measurement), 6 (trading of emission-reduction credits among Annex I countries), 7 (submission of national inventories and supplementary information), 11 (financial assistance and technology transfer to developing country parties), and 12 (Clean Development Mechanism). Entry into force of the Kyoto Protocol requires ratification by at least 55 countries, including Annex I countries accounting among them for 55% of that group's GHG emissions in 1990. As of 28 April 2003, 108 countries had ratified, including 31 Annex I countries accounting for 43.9% of the 1990 Annex I emissions. The ratification of Russia, which is expected, would be enough to bring the Treaty into force.

Mitigation: The IPCC defines "mitigation" as measures to reduce the emissions or enhance the sinks of greenhouse gases. Thus, in IPCC usage, the term refers to mitigating the drivers of climate change, not to mitigating the consequences, measures for which could also include geotechnical engineering interventions to try to offset what would otherwise be the climatic impacts of increased GHG concentrations and adaptation to reduce the costs of climate changes that are not avoided. Adaptation is considered separately from mitigation by the IPCC, but it does not seem that offsetting geotechnical interventions have been given much attention.

Montreal Protocol: Agreed in 1987, the Montreal Protocol on Substances that Deplete the Ozone Layer limited production and consumption of the five chlorofluorocarbons (CFCs) most destructive to stratospheric ozone and three bromine compounds called halons. Subsequent modifications tightened these restrictions and added 10 additional CFCs, carbon tetrachloride, and methyl chloroform. Although the gases regulated by the Montreal Protocol happen to be GHGs (as is ozone itself), the Protocol was motivated by concerns relating not to climate change but to depletion of the stratospheric ozone layer that shields Earth=s surface from cancer-causing ultraviolet radiation. The Montreal Protocol embodies important precedents for climate agreements to come, however, including developed/developing-country transfers of technology and financing and trading of production rights among participating nations.

UN Framework Convention on Climate Change (UNFCCC): Enacted at the 1992 AEarth Summit@ in Rio de Janeiro, as of 17 February 2003 the UNFCCC had been ratified by the United States and 187 other nations. It calls for Astabilization of GHG concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system@. The most important provisions of the UNFCCC are in its Article 4, dealing with commitments, including that: all parties shall develop, update, and publish national inventories of anthropogenic emissions by sources and removals by sinks of all GHGs not controlled by the Montreal Protocol; all parties will formulate, publish, and implement national programs to mitigate climate change by addressing anthropogenic sources and sinks of GHGs; all parties will cooperate in the development, diffusion, and transfer of technologies to control, reduce, or prevent emissions of anthropogenic GHGs; and Annex I parties will aim to reduce their emissions of carbon dioxide and other GHGs to 1990 levels by the year 2000. As a Senate-ratified treaty, the UNFCC is the "law of the land" in the United States, but one can question whether a serious effort has been made to comply with it.

Appendix B. Quotations from the National Academy of Sciences and the IPCC

Quotations from the Summary, *Climate-Change Science: An Analysis of Some Key Questions*, Committee on the Science of Climate Change, National Research Council / The National Academies, 2001

"Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures are, in fact, rising. The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes is also a reflection of natural variability. Human-induced warming and associated sea-level rises are expected to continue through the 21st century." (p 1)

"The mid-range model estimate of human induced global warming by the Intergovernmental Panel on Climate Change (IPCC) is based on the premise that the growth rate of climate-forcing agents such as carbon dioxide will accelerate. The predicted warming of 3°C (5.4°F) by the end of the 21st century is consistent with the assumptions about how clouds and atmospheric relative humidity will react to global warming. This estimate is also consistent with inferences about the sensitivity of climate drawn from comparing the sizes of past temperature swings between ice ages and intervening warmer periods with the corresponding changes in climate forcing." (p 1)

"The committee generally agrees with the assessment of human-caused climate change presented in the IPCC Working Group I (WGI) scientific report, but seeks here to articulate more clearly the level of confidence that can be ascribed to those assessments and the caveats that need to be attached to them." (p 1)

"The IPCC=s conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue. ... Despite the uncertainties, there is general agreement that the observed warming is real and particularly strong within the last 20 years." (p 3)

"The predicted warming is larger over higher latitudes than over low latitudes, especially during winter and spring, and larger over land than over sea. Rainfall rates and the frequency of heavy precipitation events are predicted to increase, particularly over the higher latitudes. Higher evaporation rates would accelerate the drying of soils following rain events, resulting in lower relative humidities and higher daytime temperatures, especially during the warm season. The likelihood that this effect could prove important is greatest in semi-arid regions, such as the U.S. Great Plains." (p 3)

"The Committee finds that the full IPCC Working Group I (WGI) report is an admirable summary of research activities in climate science, and the full report is adequately summarized in the *Technical Summary*. The *Summary for Policymakers* reflects less emphasis on communicating the basis for uncertainty and a stronger emphasis on areas of major concern associated with human-induced climate change. This change in emphasis appears to be the result of a summary process in which scientists work with policy makers on the document. Written responses from U.S. coordinating and lead scientific authors to the committee indicate, however, that (a) no changes were made without the consent of the convening lead authors (this group represents a fraction of the lead and contributing authors) and (b) most changes that did occur lacked significant impact." (p 4)

Committee: RALPH J. CICERONE *(Chair)*, University of California, Irvine
ERIC J. BARRON, Pennsylvania State University, University Park
ROBERT E. DICKINSON, Georgia Institute of Technology, Atlanta
INEZ Y. FUNG, University of California, Berkeley
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F. SHERWOOD ROWLAND, University of California, Irvine
EDWARD S. SARACHIK, University of Washington, Seattle

Quotations from the *Summary for Policymakers: A Report of Working Group I (The Science of Climate Change) of the Intergovernmental Panel on Climate Change*, Intergovernmental Panel of Climate Change 3rd Assessment Report, IPCC, 2001[12]

"The global average surface temperature (the average of near surface air temperature over land, and sea surface temperature) has increased since 1861. Over the 20th century, this increase has been 0.6∀0.2°C." (p 2)

"Globally, it is very likely[13] that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record, since 1861." (p 2)

"The atmospheric concentration of carbon dioxide (CO_2) has increased by 31% since 1750. The present CO_2 concentration has not been exceeded during the past 420,000 years and likely not during the past 20 million years. The current rate of increase is unprecedented during at least the past 20,000 years." (p 7)

"Natural factors have made small contributions to radiative forcing over the past century. ... The combined change in radiative forcing of the two major natural factors (solar variation and volcanic aerosols) is estimated to be negative [a cooling effect] for the past two, and possibly the past four, decades." (p 9)

"There is new and stronger evidence that most of the warming observed over the past 50 years is attributable to human activiities. ... In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the past 50 years is likely to have been due to the increase in greenhouse gas concentrations." (p 10)

"Emissions of CO_2 due to fossil fuel burning are virtually certain to be the dominant influence on the trends in atmospheric CO_2 concentration during the 21st century. ... By 2100, carbon cycle models project atmospheric CO_2 concentrations of 540 to 970 ppm for the illustrative [IPCC] scenarios (90 to 250% above the concentration of 280 ppm in the year 1750)." (p 12)

"The globally averaged surface temperature is projected to increase by 1.4 to 5.81C over the period 1990 to 2100. ... The projected rate of warming is much larger than the observed changes during the 20th century and is very likely to be without precedent during at least the past 10,000 years..." (p 13).

"Larger year to year variations in precipitation are very likely over most areas where an increase in mean precipitation is projected." (p 13)

"Tide-gauge data show that global average sea level rose between 0.1 and 0.2 metres during the 20th century. ... Global mean sea level is projected to rise by 0.09 to 0.88 metres between 1990 and 2100, for the full range of [IPCC] scenarios." (pp 4, 16)

"It is likely that warming associated with increasing greenhouse gas concentrations will cause an increase of Asian summer monsoon precipitation variability." (p 16)

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[12] The WGI Summary for Policymakers was approved in Shanghai in January 2001 by delegations from 99 IPCC member governments, which included most of the 122 lead authors and many of the 515 contributing authors of the full WGI report, as well political representatives of the governments involved.

[13] Terminology used in the WGI Third Assessment Report (including the Summary for Policymakers) to convey degrees of confidence: *virtually certain* = greater than 99% chance that a result is true; *very likely* = 90-99% chance; *likely* = 66-90% chance; *medium likelihood* = 33-66% chance; *unlikely* = 10-33% chance; *very unlikely* = 1-10% chance; *exceptionally unlikely* = less than 1% chance.

Appendix C: Role of Anthropogenic Carbon Dioxide in Global Climate Change

The relative importance of different influences on global climate is customarily expressed in terms of the effective "radiative forcing" associated with the factor of interest. The radiative forcing is defined as the net change in the flow of radiant energy at the top of the tropopause – the boundary between the troposphere and the stratosphere – and is measured in watts per square meter (W/m2) averaged over the globe, with a net increase in the downward direction considered positive. The details of this concept need not concern us here, except to note that it is also customary to express the "sensitivity" of global climate to disturbances imposed upon the climate system in terms of the change in global-average surface temperature that would result, after a new equilibrium had been reached, from the +3.7 W/m2 of radiative forcing associated with a doubling of the pre-industrial concentration of atmospheric carbon dioxide. This sensitivity is currently estimated to be 3±1.5 degrees C, meaning the range of plausible values is 1.5-4.5 degrees C and the central estimate is 3 degrees C. Thus the central estimate of the sensitivity can also be expressed as (3 degrees C) / (3.7 W/m2) = 0.8 degrees C of temperature change per W/m2 of positive radiative forcing.

Measured against the baseline of pre-industrial conditions (taken to be the year 1750), the best estimates of the radiative forcings resulting from anthropogenic changes to the atmosphere up to the year 2000 are: CO2 = +1.5 W/m2; well-mixed non-CO2 greenhouse gases (mainly methane, nitrous oxide, and halocarbons) = 1.0 W/m2; net effect of increased tropospheric and decreased stratospheric ozone = +0.2 W/m2; direct effects of absorptive particles = +0.2 W/m2; direct effects of reflective particles = -0.7 W/m2; and indirect effects of particles = -0.8 W/m2. (The direct effects are the reflective and absorptive effects of the particles themselves; the indirect effects relate to the role of particles in cloud formation.) Thus the net effect of anthropogenic changes in atmospheric composition through the year 2000 is a radiative forcing of 1.5 + 1.0 + 0.2 + 0.2 – 0.7 – 0.8 = 1.4 W/m2, with CO2 accounting for 1.5/2.9 = 52% of the positive influence. (Viewed another way, the CO2 warming effect is greater than the net warming, which means without the CO2 increase the net anthropogenic effect would be a cooling.) The increase in atmospheric CO2 concentration that gave rise to this contribution was from 280 parts per million by volume (ppmv) in 1750 to 370 ppmv in 2000.

The central estimate of the Intergovernmental Panel on Climate Change (IPCC) for the effect of variation of the sun's output for the period 1750-2000 is +0.3 W/m2 and the central estimate of the effects of land-use changes that have changed the reflectivity of Earth's surface is -0.2 W/m2. This means the central estimate of the total radiative forcing from 1750 to 2000 is 1.4 + 0.3 – 0.2 = 1.5 W/m2. At a sensitivity of 0.8 degrees C per W/m2, this would correspond to an equilibrium temperature increase of 1.5 W/m2 x 0.8 degrees C per W/m2 = 1.2 degrees C. The best estimate for the temperature increase actually observed over this period is 0.7±0.2 degrees C. (It is to be expected that the observed temperature change would not have reached the equilibrium value associated with current radiative forcing because of the time lag caused by immense thermal inertia of the oceans.)

A middle-of-the road scenario for the evolution of population, economic activity, emissions, and concentrations through the middle of the 21st century (called IS92a by the IPCC and sometimes called "business as usual" by others, although it entails eventual stabilization of world population and continuous progress in lowering the energy intensity of economic activity and the carbon intensity of energy supply) leads to CO2 concentrations of 500 ppmv in 2050 and 750 ppmv in 2100. The corresponding radiative forcing from CO2 alone would then be 3.1 W/m2 in 2050 and 5.3 W/m2 in 2100. Particle effects are expected to become relatively less important in the 21st century, because there are strong incentives (and capabilities) for reducing particle emissions in order to reduce health impacts and acid precipitation. If the IS92a scenario is adjusted to take account of the lower particle concentrations now thought likely, net atmospheric forcing would be about 4.2 W/m2 in 2050 and 6.6 W/m2 in 2100, corresponding to equilibrium average surface-temperature increases (from the pre-industrial values) of 3.4 and 5.3 degrees C, respectively. The CO2 contribution would be 75% and 80% of the net warming effect in 2050 and 2100, respectively, although somewhat smaller fractions of the gross warming before the cooling effects of particles are subtracted.

Appendix D: How Much C-Free Energy Is Needed To Avoid Exceeding a Doubling of the Preindustrial CO2 Concentration?

An updated version of the IPCC's IS92a "middle-of-the-road" (sometimes called "business as usual") scenario for the 21st century yields the following values for key parameters.

	2000	2030	2050	2100
Population, billions	6.1	8.5	9.8	11.1
World economic product, trillion ppp-2000 US dollars	45	105	170	440
Primary energy, exajoules	450	810	1120	1800
Fossil-fuel C emissions in CO2, gigatons of C	6.4	10.9	14.3	20.8

Here ppp-2000 US dollars refer to figures corrected for purchasing power parity using World Bank conversions. Of the 450 exajoules (EJ) of energy being supplied in 2000, 350 EJ came from conventional fossil-fuel technologies and 100 EJ came from carbon-free sources: nuclear energy, biomass, hydropower, and other renewables. (Taking biomass to be "carbon free" amounts to assuming that the biomass fuels are harvested sustainably, i.e., that each year's take is replaced by new growth.)

An emissions trajectory that corresponds to stabilization of the atmospheric concentration of CO2 at 550 parts per million by volume and that falls in the middle of the range of trajectories leading to this result, avoiding either very large reductions very soon or the need to reduce emissions very steeply later, would entail total CO2 emissions (from fossil fuels, cement manufacture, and deforestation) of 11.1 GtC in 2030, 10.8 GtC in 2050, and 7.0 GtC in 2100. (See T. M. L. Wigley, 2002, cited at Note 5 in the main text.) Let us assume for simplicity (and optimistically) that emissions from deforestation, taken to be 1.5 GtC/year in 2000, can be reduced to 1.0 GtC/yr by 2030, 0.5 GtC/yr by 2050, and zero by 2100. Let us assume further that the "cement intensity" of economic activity decreases at about 1.0 percent per year, so that CO2 emissions from cement manufacture are about 0.4 GtC/year in 2030, 0.6 GtC/yr in 2050, and 0.8 GtC/yr in 2100. It follows that the "allowed" carbon emissions from fossil fuels on our chosen stabilization trajectory will be 11.1 – 1.0 – 0.4 = 9.7 GtC in 2030, 10.8 – 0.5 – 0.6 = 9.7 GtC in 2050, and 7.0 – 0 – 0.8 = 6.2 GtC in 2100.

If we now make the further simplifying assumption that the mix of conventional fossil-fuel technologies being used emits the same amount of carbon per EJ of conventional fossil energy throughout the century (i.e., the year 2000 ratio of 6.4 GtC / 350 EJ of fossil energy), then we can compute the amounts of conventional fossil-fuel that would yield the indicated emissions in 2030, 2050, and 2100. These amounts are 530 EJ for 2030 and 2050 and 340 EJ for 2100. By subtraction from the total primary energy requirements in the table, the carbon-free energy requirements for these three years are 280, 590, and 1460 EJ, or roughly 3, 6, and 15 times the carbon-free energy being supplied in 2000.

If the rate of reduction of the energy intensity of economic activity worldwide throughout the 21st century were 2%/year instead of the 1%/year assumed in the middle-of-the-road scenario above, the total primary energy requirements for 2030, 2050, and 2100 would become 600, 670, and 650 EJ, respectively, and the requirements for carbon-free energy would be 70, 140, and 310 EJ, respectively. The tremendous leverage of doubling the rate of improvement of energy intensity is evident – it reduces the growth of carbon-free energy needed in the 21st century from a 15-fold increase to a 3-fold increase.

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Appendix E: US Federal Energy-Technology R&D: Congressional Appropriations, Administration Requests, and PCAST Recommendations (10^6 as-spent-$)

	effic	renew	foss	nucl fiss	nucl fusn	total
FY98 appropriation	437	272	356	7	223	1295
FY99 appropriation	503	336	384	30	222	1475
Admin request	594	372	383	44	228	1621
PCAST reccmdtn	615	475	379	66	250	1785
FY00 appropriation	552	310	404	40	250	1556
Admin request	655	398	340	41	222	1656
PCAST reccmdtn	690	585	406	86	270	2037
FY01 appropriation	600	375	433	59	255	1722
Admin request	630	410	385	52	247	1724
PCAST reccmdtn	770	620	433	101	290	2214
FY02 appropriation	617	386	577	68	248	1896
Admin request	475	237	333	39	255	1339
PCAST reccmdtn	820	636	437	116	320	2329
FY03 Admin request	561	408	483	89	257	1798
PCAST reccmdtn	880	652	433	119	328	2412

Notes: effic = energy end-use efficiency, renew = renewables, foss = fossil-fuel technologies, nucl fiss = nuclear fission, nucl fusn = nuclear fusion. The indicated figures are the energy R&D portions of the corresponding DOE budget line items. For example, the figures for efficiency do not include the low-income weatherization portion of the energy-efficiency budget line, and the nuclear-fission figures do not include the space-power and medical-isotope portions of the nuclear-fission budget line.

Appendix F: The George W. Bush Administration's Climate Policy

The climate section ("A New Approach on Global Climate Change") of the White House Fact Sheet, "President Bush Announces Clear Skies & Global Climate-Change Initiatives", released 14 February 2002, is quoted in what follows verbatim and in its entirety.

The President has committed America to an aggressive new strategy to cut greenhouse gas intensity by 18% over the next 10 years. The initiative also supports vital climate change research and ensures that America's workers and citizens of the developing world are not unfairly penalized. The President's initiative puts America on a path to slow the growth of greenhouse gas emissions, and -- as the science justifies -- to stop, and then reverse that growth.

- **Cutting Greenhouse Gas Intensity by 18 Percent Over the Next 10 Years**. Greenhouse gas intensity is the ratio of greenhouse gas emissions to economic output. The President's goal seeks to lower our rate of emissions from an estimated 183 metric tons per million dollars of GDP in 2002, to 151 metric tons per million dollars of GDP in 2012. By significantly slowing the growth of greenhouse gases, this policy will put America on a path toward stabilizing GHG concentration in the atmosphere in the long run, while sustaining the economic growth needed to finance our investments in a new, cleaner energy structure. America is already improving its GHG intensity; new policies and programs will accelerate that progress, avoiding more than 500 million metric tons of GHG emissions over the next ten years -- the equivalent of taking nearly one out of every three cars off the road. This goal is comparable to the average progress that nations participating in the Kyoto Protocol are required to achieve.

- **A New Tool to Measure and Credit Emissions Reductions**. The U.S. will improve its GHG registry to enhance measurement accuracy, reliability and verifiability, working with and taking into account emerging domestic and international approaches. These improvements will give businesses incentives to invest in new, cleaner technology and voluntarily reduce greenhouse gas emissions.

- **Protect and Provide Transferable Credit for Emission Reductions**. The President will direct the Secretary of Energy to recommend reforms to: (1) ensure that businesses that register voluntary reductions are not penalized under a future climate policy, and (2) give credit to companies that can show real emissions reductions.

- **Reviewing Progress on Climate Change and Taking Additional Action if Necessary in 2012**, which may include a broad, market-based program, as well as additional initiatives to accelerate technology. If, in 2012, we find that we are not on track toward meeting our goal, and sound science justifies further policy action, the United States will respond with additional measures that may include a broad, market-based program as well as additional incentives and voluntary measures designed to accelerate technology development and deployment.

- **Unprecedented Funding for Climate Change-Related Programs**: The President's budget in FY2003 provides $4.5 billion for global-climate-change-related activities -- a $700 million increase. This includes the 1st year of funding for a 5-year, $4.6 billion commitment to tax credits for renewable energy sources.

- **A Comprehensive Range of New and Expanded Domestic and International Policies**, including: expanded research and development of climate-related science and technology; expanded use of renewable energy; business sector challenges; improvements in the transportation sector; incentives for sequestration; enhanced support for climate observation and mitigation in the developing world.

- **A Better Alternative to the Kyoto Protocol**. Rather than making drastic reductions in greenhouse gas emissions that would put millions of Americans out of work and undermine our ability to make long-term investments in clean energy - as the Kyoto Protocol would have required - the President's growth-based approach will accelerate the development of new technologies and encourage partnerships on climate change issues with the developing world.

Appendix G: The Arithmetic of the George W. Bush Climate Plan

The following table shows the actual performance of the US economy between 1990 and 2000 with respect to growth of real Gross Domestic Product (GDP, measured in billions of 2001 dollars), greenhouse gas emissions (measured as millions of tons of "carbon equivalent", where this measure converts all greenhouse gases into their equivalents in carbon embedded in CO2), and the ratio of greenhouse-gas emissions to GDP (tons of carbon equivalent per million dollars).

	REAL GDP (Bn 2001 $)	GHG (Mt CE)	GHG/GDP (tCE / M$)
1990	7379	1678	227
2000	10146	1906	188
change	*+37.5%*	*+13.6%*	*-17.4%*

One sees that, in this decade, real GDP increased 37.5%, GHG emissions increased 13.6%, and the carbon intensity of GDP decreased 17.4%. The Bush administration's projections for the decade 2002-2012, quoted in the 14 February 2002 White House Fact Sheet on the administration's climate plan, were as follows:

	REAL GDP (Bn 2001 $)	GHG (Mt CE)	GHG/GDP (tCE / M$)
2002	10475	1917	183
2012	14483	2187	151
change	*+38.3%*	*+14.1%*	*-17.5%*

Clearly, the projected performance with respect to reduction in carbon intensity of economic activity is virtually identical to the performance experienced in the decade 1990-2000, without benefit of the Bush initiatives. If one computes the figures for the entire period 1990-2012, they come out as follows:

	REAL GDP (Bn 2001 $)	GHG (Mt CE)	GHG/GDP (tCE / M$)
change 1990-2012	*+96.3%*	*+30.3%*	*-33.5%*
avg Kyoto target for 1990-2012		-5.0%	

The increase of more than 30% from 1990 emissions is a far cry from the average Kyoto target for industrialized nations, which the Bush document itself characterizes as a 5 percent reduction.

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