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Global Climate Change and the Risks to Coastal Areas from Hurricanes and Rising Sea Levels: The Costs of Doing Nothing

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GLOBAL CLIMATE CHANGE AND THE RISKS TO COASTAL AREAS FROM HURRICANES AND RISING SEA LEVELS: THE COSTS OF DOING NOTHING

by Robert L. Glicksman*

I. INTRODUCTION

Many Americans horrified by the aftermath of Hurricane Katrina in late summer 2005 sought an explanation for the nation's failure to avert that disaster or to deal with it adequately once the storm had hit land. Candidates for bearing the lion's share of the blame were not difficult to identify. They included local governments, the governments of the states located along the Gulf Coast, the Army Corps of Engineers, high-ranking officials in the Department of Homeland Security and Federal Emergency Management Agency, and the President of the United States. The nation's attention also focused on the question of how to ensure more effective preparation for future storms such as category 4 or 5 hurricanes. Among those public officials addressing that question were subcommittees of both Houses of Congress, the Army Corps of Engineers, and the White House. These officials analyzed questions such as why the levees broke and why evacuation plans did not effectively remove people from harm's way.

One of the questions posed by scientists following Katrina was whether global climate change has had or will have an impact on hurricane intensity and frequency, resulting in more storms as ferocious as Katrina. Several propositions seem fairly uncontroversial. First, there is general agreement that it is impossible to link the intensity of any particular storm to the effects of global climate change. Second, it seems to be well accepted that there is no evidence yet to support the claim that climate change will affect hurricane frequency. Third, many scientists agree that climate change has the potential to induce more intense hurricanes.

Other propositions concerning the relationship between climate change and hurricane activity are subject to debate, however, among the scientific community. Some scientists assert that increasing air and water temperatures linked to human-induced climate change have already made intense storms such as category 4 or 5 hurricanes in the North Atlantic more common. Other scientists vigorously contest that premise, arguing that any recent increase in storm intensity is part of a natural cycle of hurricane activity and that there is no convincing evidence that it has anything to do with human-

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induced climate change. In addition, there is no consensus on the relative importance of climate change as a factor in future hurricane trends. Some scientists take the position that, even if climate change has the potential to spawn more intense hurricanes, the natural hurricane cycle in the North Atlantic is likely to be a more important contributing factor to future hurricane intensity in that region than global climate change. The debate within the scientific community over these questions continues to rage, although it may not have received as much attention in the popular press following Katrina as questions surrounding levee design and emergency preparedness.

This article addresses the possible connection between global climate change and the increased risk of powerful hurricanes in the North Atlantic Ocean. Part II briefly describes the overwhelming scientific consensus that global warming is occurring and that human activities are significantly contributing to it. Part III explores the scientific literature concerning the relationship between global climate change and the risks of increased coastal flooding and more severe hurricanes. Part III A surveys the scientific literature on the link between global climate change and rising sea levels. It concludes that there is a consensus among scientists that global climate change has already caused ocean levels to rise, creating an increased risk of coastal flooding, and that further warming will increase that risk. Scientists do not agree on the degree of sea level rise expected to result from climate change. Part III B discusses the evidence (or lack thereof) of a link between global climate change and increases in hurricane intensity. It concludes that, although it is impossible to demonstrate a cause-and-effect relationship between global climate change and the occurrence or strength of any particular storm, there is a respectable and growing body of scientific opinion to support the proposition that human-induced climate change has created an environment conducive to more intense tropical cyclones such as hurricanes.

Part IV analyzes whether the federal government is taking sufficient steps to mitigate two risks associated with continued changes in global climate that face low elevation communities located near coastal waters, such as New Orleans: the risk that these communities will experience flooding as sea levels rise, and the risk that they will suffer from the effects of more catastrophic category 4 or 5 hurricanes on the Saffir-Sampson Hurricane Scale. The first two sections of Part IV identify a series of environmental and energy policy choices that have the potential to either mitigate or exacerbate future increases in air and water temperatures. The article concludes that the federal government has missed important opportunities to pursue policies that have the potential to mitigate human-induced climate change. Further, some current federal policies not only fail to address the risk of adverse effects linked to further global climate change, but make it likely that the activities most apt to contribute to climate change will increase rather than decrease.

The third section of Part IV provides information comparing the costs and benefits of taking steps to abate global climate change with the costs and benefits of failing to do so, including but not limited to the costs of increased costs of storm damage and coastal flooding. The final section of Part IV inquires whether Hurricane Katrina has altered public perceptions of the risks posed by global climate change in ways that makes

the public likely to demand more forceful governmental responses to those risks than it has to date. It concludes that, while Katrina has not yet proven to be the kind of seminal event associated with the adoption of major federal environmental legislation in the past, it has probably marginally increased public awareness of and concern about the consequences of global climate change. These changes in public perception should increase demand for policymakers at all levels of government to craft environmental and energy policies designed to reduce greenhouse gas emissions in the United States as a means of mitigating the potential adverse effects of global climate change.

II. GLOBAL CLIMATE CHANGE AND ITS CAUSES

Although a link between human activity and increasing global temperatures has been suspected for years, not all scientists were willing to confirm that link. As recently as a decade ago, the Congressional Research Service (CRS) stated, for example, that "the vast majority of knowledgeable scientists" could not state beyond a reasonable doubt that global climate change, including severe weather events such as hurricanes, "are attributable to global warming, at least at the present time."[1] The report stated that scientists working for the Intergovernmental Panel on Climate Change (IPCC) had acknowledged a "discernable" human impact on the global climate system, but that "the question is now raised whether scientists can affirm a 'smoking gun,' which would indicate that humans are indeed the cause of recent climatic change and would be responsible for future global warming."[2]

Today few reputable scientists dispute the existence of such smoking guns.[3] The strengthening consensus is reflected in recent studies sponsored by the federal government. Just five years after publication of the CRS report, a National Academy of Sciences report concluded that "[g]reenhouse gases [GHGs] 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."[4] Similarly, in 2002, the State Department released a report in which it stated that GHGs are accumulating in the Earth's atmosphere as a result of human activities, causing global mean surface air temperature and subsurface ocean temperature to rise."[5] The Report added, however, that "[w]hile the changes observed over the last several decades are

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[1] CONGRESSIONAL RESEARCH SERVICE, GLOBAL CLIMATE CHANGE (March 18, 1996).
[2] *Id*.
[3] *See* Margaret Kriz, *No Silver Bullet*, NAT'L J., Aug. 5, 2006, at 16, 18 (asserting that "[t]he vast majority of scientists who study Earth's climate agree that the planet is warming, and they blame the greenhouse gases that accumulate in the atmosphere and prevent heat from escaping").
[4] Katherine Seelye & Andrew Revkin, *Panel Tells Bush Global Warming Is Getting Worse*, N.Y. TIMES, June 7, 2001, at A1. "Global surface temperature has increased ~0.2° C per decade in the past 30 years." James Hansen, *Global Temperature Change*, 103 PROC. OF THE NAT'L ACAD. OF SCI. 14288 (Sept. 25, 2006).
[5] United States Department of State, U.S. Climate Action Report, Third National Communication Under the United Nations Framework Convention on Climate Change (May 2002), *available at* http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsUSClimateActionReport.html.

likely due mostly to human activities, we cannot rule out that some significant part is also a reflection of natural variability."[6]

The passage of time continues to minimize the uncertainties surrounding the causes of global climate change. The Climate Change Science Program, which coordinates and integrates scientific research on climate change supported by thirteen U.S. federal departments and agencies, issued a report in 2004 in which it found that although temperature changes in North America from 1900 to 1949 were probably due to natural climate variation, changes between 1950 and 1999 were unlikely to be due only to natural climate variations. "Observed trends over this period are consistent with simulations that include anthropogenic forcing from increasing atmospheric [GHGs] and sulfate aerosols."[7]

In early 2005, the International Climate Change Taskforce (ICCT) issued a report on the status of climate change that endorsed the conclusion that human activity has contributed to global climate change. The ICCT was established by three leading think tanks, the Institute for Public Policy Research in the United Kingdom, the Center for American Progress in the U.S., and the Australia Institute. At the time, the ICCT was co-chaired by Stephen Byers, a Member of Parliament in the United Kingdom, and Senator Olympia Snowe of Maine. The ICCT report concluded that "[t]he international consensus of scientific opinion, led by the [IPCC], is agreed that global temperature is increasing and that the main cause is the accumulation of carbon dioxide and other GHGs in the atmosphere as a result of human activities. Scientific opinion is also agreed that the threat posed will become more severe over coming decades."[8] The report asserted that the cost of failing to mobilize to address this threat is likely to be extremely high, both in economic and social and human terms. "Impacts on ecosystems and biodiversity are likely to be devastating. Preventing dangerous climate change, therefore, must be seen as a precondition for prosperity and a public good, like national security and public health."[9]

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[6] *Id*. *See also* T.M.L. Wigley et al., *The Observed Global Warming Record: What Does It Tell Us?*, 94 PROC. OF THE NAT'L ACAD. OF SCI. 8314 (Aug. 5, 1997) (finding "convincing evidence for a discernable human influence on global climate," but stating that "further work is required to better quantify the magnitude of the human influence").

[7] CLIMATE CHANGE SCIENCE PROGRAM AND THE SUBCOMMITTEE ON GLOBAL CHANGE RESEARCH, A SUPPLEMENT TO THE PRESIDENT'S FISCAL YEAR 2004 AND 2005 BUDGETS, OUR CHANGING PLANET: THE U.S. CLIMATE CHANGE SCIENCE PROGRAM FOR FISCAL YEARS 2004 AND 2005 (August 25, 2004), *available at* http://www.usgcrp.gov/usgcrp/Library/ocp2004-5/default.htm.

[8] MEETING THE CLIMATE CHALLENGE: RECOMMENDATIONS OF THE INTERNATIONAL CLIMATE CHANGE TASKFORCE (January 2005), at 1, *available at* http://72.14.203.104/search?q=cache:JyXsrQKZ-b0J:www.tai.org.au/Publications_Files/Papers%26Sub_Files/Meeting%2520the%2520Climate%2520Challenge%2520FV.pdf+meeting+the+climate+change&hl=en&gl=us&ct=clnk&cd=3. *See also* Brief of *Amici Curiae* Climate Scientists David Battisti et al. in Support of Petitioners, Commonwealth of Massachusetts v. U.S. Environmental Protection Agency, at 12, No. 05-1120 (U.S. Aug. 31, 2006) (stating that "[i]t is virtually certain that what has been observed so far is only the beginning, and that continued greenhouse gas emissions along current trajectories will cause additional warming of the earth system as a whole") [hereinafter Climate Change Scientists Brief].

[9] MEETING THE CLIMATE CHALLENGE, *supra* note 8, at 1.

In 2006, a major report presented to the British government concluded that "[t]he causal link between [GHGs] and global temperatures is well established, founded on principles established by scientists in the nineteenth century."[10] The report added that "[t]he scientific evidence that climate change is a serious and urgent issue is now compelling. It warrants strong action to reduce greenhouse-gas emissions around the world to reduce the risk of very damaging and potentially irreversible impacts on ecosystems, societies and economies."[11] A group of climate scientists stated in 2006 that the evidence of climate changes such as rising global temperatures, retreat of glaciers, and rising sea levels is "so compelling that it has crystallized a remarkable consensus within the scientific community: climate warming is happening, and human activities are very likely a significant causal factor."[12]

Even before scientific opinion had so firmly coalesced around the conclusion that human activities are significantly contributing to global climate change, astute public policymakers had reached an apparent consensus around a related "critical point." A Senate Committee Report on the legislation that was subsequently enacted as the 1990 amendments to the Clean Air Act[13] stated forcefully that

> by the time there is scientific proof for every detail of the problem, it will be too late to avoid the most devastating impacts of an intensified greenhouse effect and global climate change. We can ill-afford to wait for 5 or 10 years of research before we take action to (1) limit the rate and extent of future climate change by reducing atmospheric emissions and concentrations of [GHGs], and (2) implement adaptation strategies for coping with the changes to which we are already committed.[14]

Sadly, this sage advice for the most part has been ignored in the formulation of domestic environmental and energy policy in the ensuing years.

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[10] STERN REVIEW ON THE ECONOMICS OF CLIMATE CHANGE 7 (Oct. 2006), *available at* http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm [hereinafter STERN REVIEW].

[11] *Id*. at iv. See *also id*., Executive Summary at i (stating that "[t]he scientific evidence is now overwhelming: climate change presents very serious global risks, and it demands an urgent global response"); *id*. at 2 (stating that "[a]n overwhelming body of scientific evidence now clearly indicates that **climate change is a serious and urgent issue**. The Earth's climate is rapidly changing, mainly as a result of increases in [GHGs] caused by human activities.").

[12] Climate Scientists Brief, *supra* note 8, at 3. *See also id*. at 9 (stating that "[t]he science of climate change indicates that increases in [GHGs] will almost certainly affect global climate and pose risks to human societies"); *id*. at 12 (stating that "[i]t is likely or very likely that human-induced increases in these [GHGs] are already causing global climate to warm").

[13] Pub. L. No. 101-549, 104 Stat. 2399 (1990).

[14] S. Rep. No. 101-228, at 379-80 (1989). More recently, Tim Flannery, Director of the South Australian Museum in Adelaide, and a Professor at Macquarie University's Division of Environmental and Life Sciences, has warned that "[i]f humans pursue a business-as-usual course for the first half of this century, I believe that the collapse of civilization due to climate change becomes inevitable." Zimmer, *Sweating It*, N.Y. TIMES BOOK REV., Mar. 12, 2006, at 8. *Cf*. Climate Scientists brief, *supra* note 8, at 15 (stating that "[d]elaying reductions in [GHG] emissions heightens the risk to human welfare because climate inertia commits us to large-scale, long term (centuries) climate change consequences before the exact nature of those consequences can be known").

III. THE EFFECTS OF GLOBAL CLIMATE CHANGE ON HURRICANES, AND SEA LEVELS

As Part II indicates, it has become increasingly clear to almost all knowledgeable observers that human activity is largely responsible for rising temperatures across the globe. It is also widely accepted that those increases have created a risk of coastal flooding due to rising sea levels, although scientists disagree on the amount of the anticipated inundation. The scientific community is currently engaged in intense debate over whether human-induced global temperature increases have already contributed to an increased risk of more frequent Katrina-like storms, or are likely to do so in the foreseeable future if human contributions to global climate change do not abate.

Assuming that human activities are responsible at least in significant part for the increasing temperatures the earth is experiencing, prudent public policymakers should consider whether to require or encourage steps to reduce human contributions to global climate change in order to reduce the risk of coastal flooding. If those who find the evidence of a link between global climate change and patterns of hurricane activity to be compelling are right, the desire to avert storm and flood-related damage that may ensue from global climate change provides another reason to take action to reduce GHG emissions. This part reviews the scientific evidence concerning the relationship between global climate change and the increased risk of coastal flooding due to rising sea levels and the increased risk of damaging hurricane activity.

A. Global Climate Change and the Risk of Damage from Rising Sea Levels

According to a recent report on global climate change submitted to the British government, "[h]uman activities are changing the composition of the atmosphere and its properties."[15] Global climate change has already begun to produce visible changes in the weather and on the earth's physical attributes. Among these changes are shifts in weather patterns, such as alterations of traditional seasonal rhythms.[16] One of the most important questions for low-lying coastal areas such as New Orleans and other communities bordering the Gulf of Mexico is whether rising global temperatures create an increased risk of severe coastal flooding due to rising sea levels. There seems to be no doubt among knowledgeable scientists that they do.[17]

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[15] STERN REVIEW, *supra* note 10, at 3.

[16] *See, e.g.*, CLEAR THE AIR, SEASON CREEP: HOW GLOBAL WARMING IS ALREADY AFFECTING THE WORLD AROUND US, *available at* http://www.cleartheair.org/seasoncreep/index.vtml; Claudia Tebaldi et al., *Going to the Extremes: An Intercomparison of Model-Simulated Historical and Future Changes in Extreme Events*, 10 CLIMATIC CHANGE 10584 (Dec. 2006).

[17] *See, e.g.*, Climate Scientists Brief, *supra* note 8, at 12 (stating that it is "very likely" that sea level rise in the 21st century will be "substantially larger and faster than that experienced in the 20th century, without precedent in the past 10,000 years"); *id*. at 13 (stating that, in the absence of reductions in emissions of GHGs, global warming "is very likely to drive melting of arctic ice sheets and further increases in global average sea level by 2100").

The IPCC reported in 1997 that "[c]oasts in many countries currently face severe sea-level rise problems as a consequence of tectonically and anthropogenically induced subsidence. An estimated 46 million people per year currently are at risk of flooding from storm surges. Climate change will exacerbate these problems, leading to potential impacts on ecosystems and human coastal infrastructure."[18]

One reason why temperature increases are responsible for an increase in sea levels is that heated water expands.[19] Another is that rising temperatures facilitate the melting of polar glaciers and ice sheets.[20] Both of these consequences have been linked to increases in GHG emissions.[21] Researchers have identified past instances of ice sheet collapse in both hemispheres corresponding to abrupt rises in ocean levels.[22] Some scientists contend that warming global temperatures have already begun to accelerate the melting of glaciers and polar ice.[23] The Arctic Council (which includes Canada, the U.S., Russia, and several Scandinavian countries) reported in 2004 that human-induced changes in arctic climate are among the largest on earth. Annual sea-ice has declined by about eight percent over the past 30 years, and arctic glaciers experienced surface-melt area of 16 percent between 1979 and 2002. Summer sea-ice may completely disappear by the end of the century.[24] Scientists measured record low levels of winter sea ice in the Arctic in 2005 and 2006. The maximum amount of winter sea ice in the Arctic fell by six percent over each of those winters, compared to a loss of only 1.5 percent per decade on

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[18] INTERNATIONAL PANEL ON CLIMATE CHANGE, IPCC SPECIAL REPORT ON THE REGIONAL IMPACTS OF CLIMATE CHANGE: AN ASSESSMENT OF VULNERABILITY (Robert T. Watson et al. eds. Nov. 1997) [hereinafter IPCC SPECIAL REPORT], *available at* http://www.grida.no/climate/ipcc/regional/index.htm.

[19] Oliver Houck, *Can New Orleans Be Saved*?, 19 TUL. ENVTL. L.J. 1, 27 (2006).

[20] "Several factors contribute to sea level change. The most important contribution to 20th and 21st century sea level rise is likely to be the thermal expansion of the ocean as it warms. Other contributions include the melting of glaciers, changes in the mass of the Antarctic and Greenland ice sheets, and (highly uncertain) changes in the terrestrial storage of water." John A. Church, *Climate Change: How Fast Are Sea Levels Rising?*, 294 SCIENCE 802 (Oct. 26, 2001).

[21] *See, e.g.*, Gerald A. Meehl et al., *How Much More Global Warming and Sea Level Rise?*, 307 SCIENCE 1769 (Mar. 18, 2005). The authors asserted that increases in concentrations of GHGs "in the atmosphere produce a positive radiative forcing of the climate system and a consequent warming of surface temperatures and rising sea level caused by thermal expansion of the warmer seawater, in addition to the contribution from melting glaciers and ice sheets." *Id*. *But cf*. Richard E. Moritz et al., *Dynamics of Recent Climate Change in the Arctic*, 297 SCIENCE 1497 (Aug. 30, 2002) (asserting that "[c]urrent understanding of physical mechanisms controlling atmospheric dynamics suggests that anthropogenic influences could have forced the recent trend [toward surface temperature warming] in the Arctic Oscillation, but simulations with global climate models do not agree").

[22] *See, e.g.*, Peter U. Clark et al., *Rapid Rise of Sea Level 19,000 Years Ago and Its Global Implications*, 304 SCIENCE 1141 (May 21, 2004).

[23] The impact of global warming on snow and ice is not limited to the Arctic and Antarctic regions of the globe. One report has concluded that temperature increases in the Rocky Mountain states have produced warmer winters and reduced snowpacks. Increased snowmelt could increase the risk of flooding, while depletion of snowpacks could reduce available drinking water supplies. See ROCKY MT. CLIMATE ORG., LESS SNOW, LESS WATER: CLIMATE DISRUPTION IN THE WEST (Stephen Saunders & Maureen Maxwell eds., Sept. 2005), *available at* http://www.rockymountainclimate.org/website%20pictures/Less%20Snow%20Less%20Water.pdf.

[24] ARCTIC COUNCIL, ARCTIC CLIMATE IMPACT ASSESSMENT (2004), *available at* http://www.acia.uaf.edu/. According to some scientists, human-caused global warming "has put the familiar Arctic past the point of no return." Andrew Revkin, *No Escape: Thaw Gains Momentum*, N.Y. TIMES, Oct. 25, 2005, at D1.

average annually since the earliest satellite monitoring in 1979.[25] One NASA scientist posited that "[t]his winter ice provides the kind of evidence that it is indeed associated with the greenhouse effect."[26]

Research published in 2006 also found that glaciers in Greenland were melting at twice the rate that they had been just a decade before.[27] In particular:

> the Greenland ice sheet lost between 192 million and 258 million tonnes of ice each year between April 2002 and April 2006 (equivalent to a volume of 212–284 km^3). This rate of ice loss is equivalent to a rise in sea level of 0.50.1 mm yr^{-1}, which is higher than many previous estimates. . . . [S]tudies also show that the rate at which ice was being lost [has] increased dramatically . . . : the loss rate in the period 2004–06 was 2.5 times higher than that between 2002 and 2004.[28]

The phenomenon has manifested itself in the form of floating tongues or ice shelves of outlet glaciers, each several hundred meters thick, breaking off. In addition, a doubling of the flow rate of the glaciers has resulted in more discharge of ice to the ocean and an increase in the mass deficit of the ice sheet.[29] Scientists also recently reported that temperatures in the Antarctic troposphere during winter warmed at a rate of 0.5° to 0.7° C per decade since the 1970s, a rate higher than previously believed.[30] Moreover, ice loss

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[25] National Aeronautics and Space Administration, *Arctic Sea Ice Hitting Major Lows in Wintertime*, *available at* http://www.nasa.gov/vision/earth/environment/seaice_meltdown.html.

[26] Seth Borenstein, *Arctic Ice Melt Alarms Scientists*, LAWRENCE JOURNAL-WORLD, Sept. 14, 2006, at 7A.

[27] Eric Rignot & Pannir Kanagaratnam, *Changes in the Velocity Structure of the Greenland Ice Sheet*, 311 SCIENCE 986 (Feb. 17, 2006). For animated videos showing the degree to which ice sheets have melted during the last couple of decades in Greenland, the Arctic,, and the Antarctic, see National Environmental Trust, *Arctic/Antarctic Ice Sheet Melting*, *available at* http://www.net.org/warming/videos.vtml.

[28] Tavi Murray, *Climate Change: Greenland's Ice on the* Scales, 443 NATURE 277 (Sept. 21, 2006). Murray added that "[r]ecords over short periods have to be treated with caution, and we cannot be certain that changes represent a profound alteration in the behaviour of the sheet. But several independent sources now confirm overall mass loss from the Greenland ice sheet, together with unexpected and rapidly changing behaviour." *Id*. *Compare* Any Cazenave, *How Fast Are the Ice Sheets Melting?*, *available at* http://www.sciencemag.org/cgi/search?src=hw&site_area=sci&fulltext=cazenave (stating that "[r]emote sensing data suggest that ice sheets currently contribute little to sea-level rise. However, dynamical instabilities in response to climate warming may cause faster ice mass loss").

[29] Julie Dowdeswell, *The Greenland Ice Sheet and Global Sea-Level Rise*, 311 SCIENCE 963 (Feb. 17, 2006). Polar ice sheets both gain (through snowfall) and lose (through surface melting) mass each year. A mass deficit reflects a loss that exceeds the gain during the same time period. *Id*. "[E]ven small imbalances between input and output will have a substantial impact on global sea level." David G. Vaughn, *How Does the Antarctic Ice Sheet Affect Sea Level Rise?*, 308 SCIENCE 1877 (June 24, 2005). Other researchers also have pointed out that "[t]he Greenland mass balance in a warming climate is a competition between increased precipitation caused by greater oceanic evaporation, and a combination of increased melting at the ice sheet surface and increased glacial discharge at the coasts" and that during the period 1992–2003 "increased melting is probably more important than increased accumulation." Isabella Velicogna & John Wahr, *Acceleration of Greenland Ice Mass Loss in Spring 2004*, 443 NATURE 329 (Sept. 21, 2006). They add that there are "indications based on radar interferometric surveys that the glacial accelerations already occurring in southern Greenland may be in the process of spreading into regions further north." *Id*.

[30] J. Turner et al., *Significant Warming of the Antarctic Winter Troposphere*, 311 SCIENCE 1914 (Mar. 31, 2006). Overall, the Earth has warmed by .7° C since around 1900. STERN REVIEW, *supra* note 10, at 5.

will accelerate global warming because ice acts as a cooling agent by reflecting solar radiation back into space.[31]

As a result of the melting of glaciers and ice sheets around the globe, sea levels are rising, and are doing so at an accelerating rate.[32] If the entire Greenland ice sheet melts, as it may do, global sea levels are expected to rise by about seven meters.[33] Rising temperatures that occurred during the 20th century are already destined to increase sea levels.[34] According to one group of researchers, even if concentrations of GHGs in the atmosphere had been stabilized in the year 2000, further global warming of about another half degree would have been inevitable. That additional warming, in turn, would cause at least three times as much rise in sea levels over the course of the 21st century as the amount that has occurred as a result of global warming during the 20th century.[35] If one accepts the premise that some rise in sea levels is foreordained,[36] the task at hand, therefore, is not to prevent future increases in global sea levels, but rather to restrict the increases that are going to occur. By another account, at current levels of GHG emissions, global temperatures are predicted to rise by another 2-3° C over the next fifty years. If emissions increase, the increase could be 3-4° C.[37] At those levels, hundreds of millions of people will be flooded each year worldwide, with large cities such as New York, London, and Tokyo being at high risk.[38]

The consequences of rising sea levels for New Orleans could be catastrophic. According to the IPCC, sea levels on the North American coasts could rise by 50 centimeters due to climate change, resulting in the inundation of from 8500 to 19,000 square kilometers of land and the elimination of as much as 50 percent of North

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[31] *See* Freedman, *Arctic Warming Portends Change for Rest of Globe, Assessment Report Warns*, GREENWIRE, Nov. 18, 2004.

[32] STERN REVIEW, *supra* note 10, at 15.

[33] *See* Murray, *supra* note28; Dowdeswell, *supra* note 29. Some scientists predict that, even if GHGs continue to experience moderate growth, almost all of the summer ice in the Arctic will be gone by the end of the 21st century, producing an open polar sea. Ice in the Antarctic is also decreasing, by as much as 36 cubic miles of ice annually. *See* Isabella Velicogna & John Wahr, *Measurements of Time-Variable Gravity Show Mass Loss in Antarctica*, 311 SCIENCE 1754 (Mar. 24, 2006); Julie Eilperin, *Antarctic Ice Sheet Is Melting Rapidly*, WASH. POST, Mar. 3, 2006, at A1. *Cf.* STERN REVIEW, *supra* note 10, at 2 (stating that if the Greenland or West Antarctic ice sheets begin to melt irreversibly, sea levels would eventually rise by 5 to 12 meters over several centuries); *id*. at 16 (same); *id*. at 56 (finding that the melting or collapse of ice sheets would raise sea levels, threatening at least 4 million square kilometers of land, which is home today to about 5% of the world's population).

[34] STERN REVIEW, *supra* note 10, at 76.

[35] Meehl et al., *supra* note 21.

[36] *But cf*. Michael Oppenheimer, *Ice Sheets and Sea Level Rise: Model Failure is the Key Issue* (June 26, 2006), *available at* http://www.realclimate.org/index.php/archives/2006/06/ice-sheets-and-sea-level-rise-model-failure-is-the-key-issue (contending that "[a]t this juncture, numerical modeling simply does not provide a credible basis for quantitative projection of ice sheet behavior in a warmer world").

[37] In the range of a 2-3° increase in global temperatures, "the Earth would reach a temperature not seen since the Pliocene around 3 million years ago. This level of warming on a global scale is far outside the experience of human civilisation." STERN REVIEW, *supra* note 10, at 12.

[38] *Id*., Executive Summary at vi. *See also id*. at 76 (finding that 22 of the world's 50 largest cities are at risk of flooding from coastal surges). "A warming of 5° C on a global scale would be far outside the experience of human civilisation and comparable to the difference between temperatures during the last ice age and today." *Id*. at 2.

America's coastal wetlands. The reduction of wetlands acreage near New Orleans will only serve to exacerbate the risk of damage from intense hurricanes.[39] The IPCC added that these projected changes probably underestimate the effects of climate change on sea levels along the Gulf Coast.[40] According to another account, relative ocean levels could rise from three to four and a half feet even without taking the melting of polar ice and glaciers into account.[41] In some parishes in New Orleans, 70 to 80 percent of the land has an elevation of two feet or less.[42] Any subsidence of the land mass in New Orleans will merely exacerbate the problem.[43] The consequences for New Orleans of unabated global temperature increases, therefore, could include permanent inundation of a significant portion of the city.[44]

Although scientists agree that sea levels will increase as a result of anthropogenically caused global climate change, they have not reached a consensus on how much they will rise. One way for policymakers to respond to the threat of coastal flooding would be to wait until the accumulation of additional information reduces the uncertainties concerning the magnitude of the threat of coastal flooding and the costs of acting to abate it. As one researcher has argued, however, "because [GHG] concentrations and ice sheet loss are effectively irreversible, policy decisions need to be made based on the information in hand, which argues that deglaciation could be triggered by a modest warming."[45] Part IV discusses some of the policies whose implementation might reduce GHG emissions, and compares the costs of pursuing those policies with the costs of doing nothing, at least in the short term.

B. Global Climate Change and the Risk of Hurricane Damage

In the days and weeks immediately following Hurricane Katrina, one of the questions addressed in the popular media[46] was whether either the existence or strength

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[39] *See* Houck, *supra* note 19, at 41 (stating that, "[g]enerally speaking, a couple of miles of these marshes will knock down a hurricane storm surge by a foot"); Jon Kusler, *Wetlands, Hurricanes, and Flood Hazards*, *in* AFTER THE STORM: RESTORING AMERICA'S GULF COAST WETLANDS at 34 (Gwen Arnold ed., 2006) (summarizing the ways in which wetlands minimize flood, erosion, and other natural hazard losses from major hurricanes).

[40] IPCC SPECIAL REPORT, *supra* note 18, *available at* http://www.grida.no/climate/ipcc/regional/512.htm.

[41] *See* Houck, *supra* note 19, at 27 (citing Micah Walker Parkin, Alliance for Affordable Energy, *Climate Change, and Louisiana*, *available at* http://www.all4energy.org/climatechange.html; JAMES G. TITUS & VIJAY K. NARAYANAN, ENVTL. PROT. AGENCY, THE PROBABILITY OF SEA LEVEL RISE (1995), *available at* http://yosemite.epa.gov/oar/globalwarming).

[42] Houck, *supra* note 19, at 27.

[43] *Id*.

[44] For animated demonstrations of the effects of rising coastal waters on various cities in the U.S., including some cities located along the Gulf of Mexico, see National Environmental Trust, *Animations Show Global Warming's Potential Effects on Coastal Cities*, *available at* http://www.net.org/globalwarming/sea_level/.

[45] Oppenheimer, *supra* note 36.

[46] In January 2006, Discover Magazine identified the relationship between hurricane intensity and global warming as its number one story of the year in science. *Year in Science*, *available at* http://www.discover.com/issues/jan-06/cover. *See also* Richard A. Kerr, *Is Katrina a Harbinger of Still More Powerful Hurricanes?*, 309 SCIENCE 1807 (Sept. 16, 2005) (referring to tabloid accounts attributing Katrina flooding to global warming).

of that particular hurricane was due to global warming.[47] There is little if any debate among scientists that this question is unanswerable. As one group of researchers put it:

> [T]here is no way to prove that Katrina either was, or was not, affected by global warming. For a single event, regardless of how extreme, such attribution is fundamentally impossible. We only have one Earth, and it will follow only one of an infinite number of possible weather sequences. It is impossible to know whether or not this event would have taken place if we had not increased the concentration of [GHGs] in the atmosphere as much as we have. Weather events will always result from a combination of deterministic factors (including [GHG] forcing or slow natural climate cycles) and stochastic factors (pure chance).[48]

It is more useful to ask whether global climate change has already contributed to the conditions that make hurricanes like Katrina possible and whether the risk of more frequent or more intense hurricane activity in the North Atlantic will rise in the future if global air and water temperatures continue to increase.[49]

1. *What Causes Hurricanes?*

Hurricanes are a form of tropical cyclone. "Tropical cyclones are low-pressure systems that originate over tropical or subtropical oceans and have organized convection and a well-defined cyclonic circulation at the surface. At maximum sustained surface wind velocities of 17 meters per second (m/s), they are called tropical storms or tropical

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[47] At least one class action tort suit has been filed in federal court in which the plaintiffs have alleged that the environmental conditions in the Gulf of Mexico which fostered the strengthening of Hurricane Katrina were "the direct result" of increasing air and water temperatures, melting polar ice caps, and increases in hurricane frequency and intensity due to global warming. *See* John P. Manard, Jr. et al., *Katrina's Tort Litigation: An Imperfect Storm*, 20-SPG. NAT. RESOURCES & ENV'T 31, 36-37 (2006) (citing Cox v. Nationwide Ins. Co. et al., Case No. 1:05CV436LG-RHW (S.D. Miss., filed Sept. 20, 2005)). The plaintiffs are owners of property damaged in Hurricane Katrina who sought to represent the owners of all insured property in Mississippi who suffered losses as a result of the hurricane. They sued insurance companies that wrote policies allegedly covering these losses, mortgage lenders that allegedly breached legal duties to maintain insurance coverage on the mortgaged property, and chemical and oil companies whose actions allegedly caused damage to the plaintiffs' property through actions that contributed to global warming. The district court refused to certify the class and required the plaintiffs to file separate actions against their insurers and mortgage lenders. The court noted that "there exists a sharp difference of opinion in the scientific community concerning the causes of global warming, and I foresee daunting evidentiary problems for anyone who undertakes to prove, by a preponderance of the evidence" that the emission of GHGs, "through the phenomenon of global warming, intensified or otherwise affected the weather system that produced Hurricane Katrina." Comer v. Nationwide Mut. Ins. Co., 2006 WL 1066645, at *4 (S.D. Miss. Feb. 23, 2006). The plaintiffs subsequently amended their complaint against the chemical and oil companies. Comer v. Murphy Oil Co., Third Amended Complaint, Case No. 1:05-cv-00436-LTS-RHW (S.D. Miss. Apr. 18, 2006); Kristin Choo, *Feeling the Heat: The Growing Debate Over Climate Change Takes on Legal Overtones*, ABA J., July 2006, at 29, 34.

[48] Stefan Rahmsdorf et al., *Hurricanes and Global Warming — Is There a Connection* (Sept. 2, 2005), *available at* http://www.realclimate.org/index.php/archives/2005/09/hurricanes-and-global-warming.

[49] *See, e.g.*, *id*. (stating that "we *can* indeed draw some important conclusions about the links between hurricane activity and global warming in a *statistical* sense").

cyclones. At 33 m/s or more, they are referred to as hurricanes" in the North Atlantic.[50] Even though understanding of the dynamics of tropical cyclones is constrained by limited data[51] and the multiplicity of factors that influence hurricane activity,[52] it is clear that a weak cyclonic circulation may intensify into a hurricane:

> Near the sea surface, friction causes the air to spiral inward toward the storm center. Clouds near the center become organized into spiral rainbands and eventually into an eye wall by the strong rotation in the vortex. As the winds strengthen and surface pressure decreases, increasing amounts of water are extracted from the warm ocean. The air rises and cools and water vapor condenses, releasing latent heat. The heating of the center of the storm leads to its intensification, thereby further increasing the surface wind and evaporation. The storm will continue to intensify in this way until the energy input by surface evaporation is balanced by the frictional dissipation.
>
> Tropical cyclones thus derive energy primarily from the evaporation of seawater and the associated condensation in convective clouds concentrated near the center of the storm. A well-developed tropical cyclone (hurricane) converts ocean heat energy into the mechanical energy of the winds, like a heat engine. . . .[53]

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[50] Lennart Bengtsson, *Warming Hurricane Threats*, 293 SCIENCE 440 (July 20, 2001). *See also* Alexandra Witze, *Meteorology: Bad Weather Ahead*, 441 NATURE 564 (June 1, 2006) [hereinafter Witze, *Bad Weather*]:

> Tropical cyclones are born over the oceans, where masses of rotating air pick up ever more energy from warm surface water. Once the winds in the mass reach 33 metres per second, a tropical cyclone is born. In the northwest Pacific, it's called a typhoon; in the Atlantic and northeast Pacific, a hurricane; elsewhere, a cyclone.

[51] *See, e.g.*, Witze, *Bad Weather Ahead*, *supra* note 50 (stating that "[t]he historical data on tropical cyclones are notoriously patchy"); *id*. (warning that "the historical record shouldn't be trusted").

[52] A combination of local and remote factors

> influence the number of waves that develop into tropical cyclones during each hurricane season. Local factors occur in the actual region and have a direct thermodynamic or dynamic connection to development. Remote factors occur away from the [main development region], but are associated (via teleconnections) with conditions in that region. All factors vary on disparate temporal and spatial scales, and there is considerable interdependence between some of them. The extremely active 1995 season, for example, resulted from the juxtaposition of virtually all of the factors known to favor development. Among the local tropical Atlantic factors are the lower stratospheric Quasi-Biennial Oscillation, sea-level pressure, lower tropospheric moisture, sea-surface temperature (SST), and vertical shear of the horizontal environmental wind.

Stanley Goldenberg et al., *The Recent Increase in Atlantic Hurricane Activity: Causes and Implications*, 293 SCIENCE 474 (July 20, 2001). *See also* B.D. Santer et al., *Forced and Unforced Ocean Temperature Changes in Atlantic and Pacific Tropical Cyclogenesis Regions*, 103 PROC. OF THE NAT'L ACAD. OF SCI. 13905, 13905 (Sept. 19, 2006) (stating that "[h]urricane activity is influenced by a variety of physical factors, such as sea surface temperatures (SSTs), wind shear, moisture availability, and atmospheric stability").

[53] Bengtsson, *supra* note 50. According to Bengtsson:

> Empirical assessment and results from comprehensive climate models are in broad agreement that the following key conditions must be met: First, tropical storms will only develop over ocean areas where the sea surface temperature is ~26ºC or more because a minimum amount of ocean heat supply is required. Second, low vertical wind shear is required, presumably because the convective cloud cells that provide the energy for the storm can only do so if their vertical structure is maintained.

Id. *See also* Kevin Trenberth, *Uncertainty in Hurricanes and Global Warming*, 308 SCIENCE 1753 (June 17, 2005) [hereinafter Trenberth, *Uncertainty in Hurricanes*] (stating that "[h]urricane activity generally

The more intense a cyclonic storm is, the greater the adverse effects it creates are likely to be. An increase of five to ten percent in hurricane wind speed due to rising water temperatures is predicted to double the annual damage costs from those storms in the United States. Increasing costs of severe weather events such as hurricanes create a risk of "large-scale shocks" to developed financial markets in countries such as the United States as the costs of insurance become higher and more volatile.[54]

2. *The Impact of Global Climate Change on Hurricanes: Dualing Hypotheses*

What have scientists reported about the relationship between global climate change and hurricane activity? Researchers appear to agree that there is no basis yet for asserting that anthropogenic climate change has affected or will affect the frequency of hurricanes that form in the North Atlantic.[55] Even though ongoing climatic changes favor enhanced convection and an increase in the frequency of thunderstorms, "to get a hurricane, these thunderstorms must first be organized into a tropical storm (which is essentially a collection of thunderstorms that develops a vortex."[56] "Model projections of how wind shear[57] in the hurricane region responds to global warming caused by increased carbon dioxide in the atmosphere tend to differ."[58] Likewise, scientists have not uncovered evidence that global climate change affects or will affect the tracks that hurricanes follow once they do form.

Questions surrounding the relationship between global climate change and hurricane intensity,[59] however, are highly contentious.[60] The issue became so heated that

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occurs over the oceans where sea surface temperatures (SSTs) exceed 26°C"); J.A. Curry et al., *Mixing Politics and Science in Testing the Hypothesis that Greenhouse Warming Is Causing a Global Increase in Hurricane Intensity*, 87 BULL. OF AMER. METEOROLOGICAL SOC'Y 1025, 1029 (Aug. 2006) (stating that "thermal energy has a prominent role in theories to estimate the upper bounds on tropical cyclone intensity" and that "there is a strong relationship between ocean thermal energy and the maximum potential intensity that can be achieved").

[54] STERN REVIEW, *supra* note 10, Executive Summary at viii.

[55] According to some sources, however, the NOAA in 2006 blocked release of a report suggesting that global warming is contributing to both the strength and frequency of hurricanes. NOAA spokespersons responded that the document was not ready for distribution. Randolph E. Schmid, *Journal: Agency Blocked Hurricane Report*, WASH. POST, Sept. 27, 2006.

[56] Trenberth, *Uncertainty in Hurricanes*, *supra* note 53.

[57] "The change in winds with height is referred to as vertical wind shear. Hurricane formation requires the winds to be fairly uniform throughout the atmosphere, meaning that they require low vertical wind shear. Hurricanes cannot form if the vertical wind shear is too high." National Weather Center, Climate Prediction Center, *Frequently Asked Questions About El Nino and La Nina*, *available at* http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensofaq.shtml [hereinafter Climate Prediction Center].

[58] Trenberth, *Uncertainty in Hurricanes*, *supra* note 53.

[59] "Tropical cyclone intensity is defined by the maximum sustained surface wind, which occurs in the eyewall of a tropical cyclone." Christopher W. Landsea, *Can We Detect Trends in Extreme Tropical Cyclones?*, 313 SCIENCE 452 (July 28, 2006) [hereinafter Landsea, *Can We Detect Trends?*].

[60] *See, e.g.*, Bengtsson, *supra* note 53 (stating that "[]how tropical cyclone frequency and intensity might respond to climate change is still a very open question"); Goldenberg et al., *supra* note 52 (stating that "[t]here have been various studies investigating the potential effect of long-term global warming on the

one scientist resigned as a contributor to the IPCC because one of his co-authors had allegedly "politicized" the process by postulating links between global warming and the 2005 hurricane season.[61]

The debate revolves around efforts to identify what is responsible for recent increases in sea surface temperatures (SSTs) that are known to be associated with more intense hurricanes.[62] Scientists have produced two hypotheses to explain recent increases in SSTs,[63] and correspondingly, in hurricane intensity in the North Atlantic.

> The climate change hypothesis asserts that changes in radiative forcing resulting from increased greenhouse gas build up in the atmosphere increases [global mean near-surface air temperatures (GT)] and causes Atlantic SST to rise, at least during the hurricane season months of August through October. On the other hand, the [Atlantic Multidecadal Oscillation (AMO)] hypothesis asserts that natural changes in the deep water circulation of the Atlantic Ocean drive hurricane season SST resulting in changes to both hurricane activity and GT. Under both hypotheses local SST plays a direct role in helping to power hurricanes by providing moist enthalpy and instability. Thus the point of departure for the two competing hypotheses is the causal connection between GT and Atlantic SST. The climate change hypothesis suggests the causality goes from GT to Atlantic SST whereas the AMO hypothesis implies it is the other way around.[64]

Some scientists break the climate change hypothesis down into three subhypotheses: (1) the frequency of intense hurricanes is increasing; (2) average hurricane intensity increases with increasing tropical SST; and (3) global tropical SST is increasing as a result of GHG emissions that contribute to global warming.[65] The proponents of the

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number and strength of Atlantic-basin hurricanes. The results are inconclusive."). *Cf.* Landsea, *Can We Detect Trends?*, *supra* note 59 (contending that further research, including reanalyses of existing storm databases, may be able to "answer the important question of how humankind may (or may not) be changing the frequency of extreme tropical cyclones").

[61] *See* Jocelyn Kaiser, *Scientist Quits IPCC Panel Over Comments*, 307 SCIENCE 501 (Jan. 28, 2006). According to one observer, "[t]he debate has got personal at times, and few are happy about it." Witze, *Bad Weather*, *supra* note 50. *See also* Curry et al., *supra* note 53, at 1033 (describing the acrimony surrounding the debate and the media's role in inflaming it). According to an editorial in *Nature*,

> [T]he science of hurricanes and global warming seems to be falling into the same trap that has ensnared climate-change research for two decades. Researchers are lining up into distressingly familiar camps, with some arguing for the link between tropical storms and climate change, and some against it. They duel at press conferences and snipe at each other on the Internet and in the literature, each side trying to dissect the other's data.

The Gathering Storm, 441 NATURE 549 (June 1, 2006).

[62] *See* Santer et al., *supra* note 52, at 13905 (asserting that past research demonstrating a correlation between SSTs and hurricane intensity "raises an important question: What are the causes of past SST changes in areas where hurricanes develop?"); Curry et al., *supra* note 53, at 1029 (asserting that "'[t]he causal link between SST and hurricane intensity was established over 50 years ago").

[63] According to one study, SSTs in the Western Pacific Ocean, "and probably the planet as a whole," have risen to within ~1° C of the maximum temperature of the past million years. James Hansen, *Global Temperature Change*, 103 PROC. OF THE NAT'L ACAD. OF SCI. 14288 (Sept. 25, 2006)

[64] James B. Elsner, *Evidence in Support of the Climate Change — Atlantic Hurricane Hypothesis*, 33 GEOPHYSICAL RESEARCH LETTERS L16705, at 1 (Aug. 23, 2006) (also stating that some studies attribute recent increases in SSTs "to a natural climate fluctuation," the AMO, while others suggest "that climate change [is] related to anthropogenic increases in radiative forcing from greenhouse-gases").

[65] Curry et al., *supra* note 53, at 1026.

AMO theory contest the third subhypothesis, and may contest the first, depending on the time frame chosen to measure changes in hurricane intensity.

a. The Climate Change Hypothesis

A correlation between rising SSTs due to human-caused global warming and increased hurricane intensity makes intuitive sense.[66] The power of hurricanes comes from the energy held in water. As Professor Oliver Houck has pointed out, "[w]arm waters are hurricane food, which is why the season comes at the end of the summer."[67] As clouds move over warm water, they are energized by the addition of water droplets that evaporate from the ocean's surface. As cloud size increases, so do the height and strength of hurricanes.[68] In addition, warmer air temperatures increase humidity levels just above the water surface, facilitating the evaporation that carries warm water droplets into the atmosphere. As evaporation increases, the clouds get larger and are more likely to be affected by the spinning of the earth's rotation that produces tropical storms.[69] Further, warmer surface ocean temperatures decrease atmospheric stability, increasing the penetration depth of a vortex and making developing tropical cyclones more resistant to vertical wind shear that inhibits the formation and intensification of tropical cyclones.[70]

Does the available evidence, based on either modeling or historical data on hurricanes in the North Atlantic, lend support to the common sense notion that increasing SSTs will fuel more intense hurricanes? Proponents of the climate change hypothesis assert that there is a correlation between increasing air and surface water temperatures due to anthropogenically caused global warming and an increase in hurricane intensity.[71] They claim that both simulation models[72] and actual historical data on past storms

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[66] *Cf.* Santer et al. *supra* note 52, at 13905 (stating that "[t]heory, observations, and modeling provide evidence of a direct link between changes in SSTs and hurricane intensity")

[67] Houck, *supra* note 19, at 28.

[68] Mark Schleifstein, *Scientists Argue Cause Behind Active Seasons*, NEW ORLEANS TIMES-PICAYUNE, July 10, 2006. *See also* Bengtsson, *supra* note 50:

> [A]lthough the number of cyclones may not increase substantially in the near future, this does not necessarily mean that the strength of the most powerful and dangerous cyclones will remain the same. Given optimum conditions in a future warmer climate, with an atmosphere potentially holding more moisture, the development of more intense cyclones cannot be excluded. This notion is supported by a high-resolution climate modeling study.

Similarly, Trenberth asserts that "once a tropical storm has formed, the changing environmental conditions [*i.e.*, increasing SSTs] provide more energy to fuel the storm, which suggests that it will be more intense than it would otherwise have been, and that it will be associated with heavier rainfalls." Trenberth, *Uncertainty in Hurricanes*, *supra* note 53.

[69] Schleifstein, *supra* note 68.

[70] Goldenberg et al., *supra* note 52.

[71] More generally, some researchers have concluded that extreme precipitation events "are likely to respond substantially to anthropogenically enhanced greenhouse forcing." Noah S. Diffenbaugh et al., *Fine-Scale Processes Regulate the Response of Extreme Events to Global Climate Change*, 102 PROC. OF THE NAT'L ACAD. OF SCI. 15774 (Nov. 1, 2005).

[72] One study of hurricane simulations reached the following conclusion:

> [A]fter about a century of climate warming in response to increasing [GHGs], the upper limits on tropical cyclone intensity imposed by the thermodynamic environment will be altered in such a

support the conclusion "that hurricanes may indeed become more destructive as tropical [SSTs] warm due to anthropogenic impacts."[73]

One prominent early spokesperson for this position, Kerry Emanuel, claimed in a paper published barely a month before Katrina that both "[t]heory and modeling predict that hurricane intensity should increase with increasing global mean temperatures."[74] Other scientists concur. According to one researcher,

> although variability is large, trends associated with human influences are evident in the environment in which hurricanes form, and our physical understanding suggests that the intensity of and rainfalls from hurricanes are probably increasing, even if this increase cannot yet be proven with a formal statistical test. Model results suggest a shift in hurricane intensities toward extreme hurricanes.[75]

Emanuel and others also claim that the empirical historical "record of net hurricane power dissipation is highly correlated with tropical sea surface temperature, reflecting well-documented climate signals, including multi-decadal oscillations in the North Atlantic and North Pacific, and global warming."[76] They assert that recent hurricane activity supports the theory that global warming and increased hurricane activity are correlated to one another. The 2005 North Atlantic hurricane season was the most active on record and caused massive damage.[77] Researchers have asserted that SSTs in the tropical North Atlantic region were at record high levels between June and

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> way as to allow for tropical cyclones with greater precipitation rates and higher intensity (by roughly half a category in our idealized calculations) than occur in the present climate.

Thomas R. Knutson & Robert E. Tuleya, *Impact of CO_2-Induced Warming on Simulated Hurricane Intensity and Precipitation: Sensitivity to the Choice of Climate Model and Convective Parameterization*, 17 J. OF CLIMATE 3477, 3494 (Sept. 15, 2004).

[73] Rahmsdorf et al., *supra* note 48.

[74] Kerry Emanuel, *Increasing Destructiveness of Tropical Cyclones Over the Past 30 Years*, 436 NATURE 686 (Aug. 4, 2005).

[75] Trenberth, *Uncertainty in Hurricanes*, *supra* note 53. *See also* Rahmsdorf et al., *supra* note 48 ("Hurricane forecast models (the same ones that were used to predict Katrina's path) indicate a tendency for more intense (but *not* overall more frequent) hurricanes when they are run for climate change scenarios."). Models that predict more intense hurricanes as sea surface temperatures rise are not limited to studies of the North Atlantic region. *See, e.g.*, Knutson et al., *Simulated Increase of Hurricane Intensities in a CO_2-Warmed Climate*, 279 SCIENCE 1018 (Feb. 13, 1998) (finding that for SST increases of about 2.2° C, simulations yielded hurricanes that were more intense by 3 to 7 meters per second for wind speed and 7 to 20 millibars for central surface pressure). *See also* T.R. Knutson & R. E. Tuleya, *Increased Hurricane Intensities with CO_2-Induced Warming as Simulated Using the GFDL Hurricane Prediction System*, 15 CLIMATE DYNAMICS 593 (1999).

[76] Emanuel, *supra* note 74.

[77] As of 2001, the period between 1995-2000 witnessed the highest level of North American hurricane activity for which reliable records exist. Goldenberg et al., *supra* note 52. The 2006 hurricane season in the North Atlantic was far less intense than the 2005 hurricane season, apparently at least in part because of the influence of El Nino. El Nino is "a large-scale ocean-atmosphere climate phenomenon linked to periodic warming in sea-surface temperatures across the central and east-central equatorial Pacific." Climate Prediction Center, *supra* note 57. El Nino contributes to fewer Atlantic hurricanes by increasing the area affected by vertical wind shear. *Id*. *See also El Nino Forms in Pacific Ocean*, CNN.com (Sept. 13, 2006) (describing opinions of government weather experts that "El Nino is helping to explain why the [2006] hurricane season is less that we expected" and that "this El Nino apparently has helped hinder storm formation in 2006").

October 2005 (0.9° C above the norm between 1901-1970) and that these unusually high temperatures "were a major reason for the record hurricane season."[78] More generally, these researchers have concluded that high SSTs "are strongly correlated with the observed increase in intensity and hurricane activity" in the North Atlantic since the 1970s and that further increases in water temperatures exacerbate the risk of future enhanced hurricane activity."[79] Emanuel interprets the historical data to "suggest that future warming may lead to an upward trend in tropical cyclone destructive potential, and — taking into account an increasing coastal population — a substantial increase in hurricane-related losses in the twenty-first century."[80]

The empirical evidence in support of a link between human-induced climate change and increased hurricane intensity is getting stronger.[81] One recent paper claims to provide the first data "to directly relate climate change to hurricane activity."[82] The author claimed that global mean near-surface air temperatures are useful in predicting SSTs in the North Atlantic, "but not the other way around."[83] He interpreted the data to support the existence of a causal connection between human-induced global air temperature increases and rising SSTs that provide the fuel for more intense hurricanes.[84] In another study financed by the U.S. Department of Energy, researchers concluded that

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[78] Kevin E. Trenberth & Dennis J. Shea, *Atlantic Hurricanes and Natural Variability in 2005*, 33 GEOPHYSICAL RESEARCH LETTERS L12704, at 1 (June 27, 2006). According to Trenberth and Shea, natural cycles were a minor factor in the record high temperatures in the tropical North Atlantic during the 2005 hurricane season. *See Global Warming Surpassed Natural Cycles in Fueling 2005 Hurricane Season, NCAR Scientists Conclude*, *available at* http://www.ucar.edu/news/releases/2006/hurricanes.shtml. According to some prognosticators, SSTs may rise by a few additional degrees in the future because of global warming. *See* Rahmsdorf et al., *supra* note 48.

[79] Trenberth & Shea, *supra* note 78, at 3, 4. *See also* C.D. Hoyos et al., *Deconvolution of the Factors Contributing to the Increase in Global Hurricane Intensity*, 312 SCIENCE 94 (April 7, 2006) (concluding that "the trend of increasing numbers of category 4 and 5 hurricanes for the period 1970-2004 is directly linked to the trend in sea-surface temperatures" and that other aspects of the tropical environment, such as wind shear, do not contribute significantly to the trend); Santer et al., *supra* note 52, at 13905 (discussing "evidence that a recent increase in the number of category 4 and 5 hurricanes is largely SST-driven"). According to one study, the smallest percentage increase in category 4 and 5 hurricanes between 1970 and 2005 occurred in the North Atlantic Ocean (compared to the North Pacific, Indian, and Southwest Pacific Oceans), but the number of cyclones and cyclone days increased during that period only in the North Atlantic. P.J. Webster et al., *Changes in Tropical Cyclone Number, Duration and Intensity in a Warming Environment*, 309 SCIENCE 1844 (Sept. 16, 2005).

[80] Emanuel, *supra* note 74. In responding to critics of his interpretation of the data on tropical cyclones, Emanuel subsequently asserted "that current levels of tropical storminess are unprecedented in the historical record and that a global-warming signal is now emerging in records of hurricane activity. This is especially evident when one looks at global activity and not just the 12% of storms that occur in the Atlantic." Kerry Emanuel, *Meteorology: Emanuel Replies*, 438 SCIENCE E13 (Dec. 22, 2005). *See also* Curry et al., *supra* note 53, at 1031 (arguing that "[g]lobal tropical SST is increasing as a result of greenhouse warming").

[81] Still other research suggests that rising ocean temperatures also may be increasing the length of the hurricane season in the North Atlantic. *See* Alexandra Witze, *Tempers Flare at Hurricane Meeting*, 441 NATURE 11 (May 4, 2006) [hereinafter Witze, *Tempers Flare*] (describing the work of Peter Webster).

[82] Elsner, *supra* note 64, at 3.

[83] *Id*. at 1.

[84] *Id*. at 1-2. According to Elsner, "[t]he warm ocean provides the heat and moisture to sustain hurricane-force winds against friction and entropy. Thus I expect that Atlantic SST causes greater hurricane activity and that the causality be detectable. . . ." *Id*. at 3.

"human-caused changes in [GHGs] are the main river of the 20th century SST increases in both [the Atlantic and Pacific] tropical cyclogenesis regions."[85] More precisely, that study concluded that "there is an 84% chance that external forcing [such as human-induced increases in GHG emissions] explains at least 67% of observed SST increases" in those regions.[86]

b. The AMO Hypothesis

Despite the theoretical, model-based, and historical data that support the existence of a correlation between global temperature increases and changes in hurricane intensity, some scientists vigorously dispute either the existence or significance of such a correlation.[87] One such scientist summarized this view as follows: "[M]odeling and theoretical studies suggest only small anthropogenic changes to tropical cyclone intensity several decades into the future."[88]

The climate change skeptics both attack the data relied on by supporters of the climate change hypothesis and provide alternative explanations of the historical evidence. Some of the climate change skeptics contend that the databases relied on in conducting the studies finding a correlation between anthropogenic contributions to climate change and recent increases in tropical cyclone intensity may have underestimated the strength of past hurricanes.[89] In particular, the National Oceanic and Atmospheric Administration stated in press releases issued in 2005 that "longer-term climate change appears to be a minor factor" in the dramatic North Atlantic hurricane cycle that occurred in that year.[90]

The alternative causes relied on by most of those who do not regard climate change as a significant contributor to increased hurricane intensity in the North Atlantic is the AMO. They argue that recent surges in Atlantic hurricane activity are part of a natural, fifty-to-seventy year multidecadal, the AMO, or at least that it is not possible to separate out the effects of the AMO from the effects of global temperature changes.[91]

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[85] Santer et al., *supra* note 52, at 13905. According to a press release that accompanied publication of the report, the study, based on the use of 22 different computer models of the climate system, shows "that the warming of the tropical Atlantic and Pacific Oceans is directly linked to human activities." Lawrence Livermore National Laboratory, News Release, *Researchers Link Human Activities to Rising Ocean Temperatures in Hurricane Formation Regions*, *available at* http://www.llnl.gov/pao/news/news_releases/2006/NR-06-09-02p.html [hereinafter LLNL News Release].

[86] Santer et al., *supra* note 52, at 13910. The lead author of the study summarized the study's findings as follows: "The bottom line is that natural processes alone simply cannot explain the observed SST increases in these hurricane breeding grounds. The best explanation for these changes has to include a large human influence." LLNL News Release, *supra* note 85.

[87] *See, e.g.*, Schleifstein, *supra* note 68.

[88] Landsea, *Can We Detect Trends?*, *supra* note 59. *See also Global Warming's Effect on Hurricane Strength Disputed in New Report*, SUN-SENTINEL, July 28, 2006, *available at* http://www.sun-sentinel.com/news/local/southflorida/sfl-0729globalwarming,1,6081492.story?ctrack=1&cset=true.

[89] Landsea, *Can We Detect Trends?*, *supra* note 59.

[90] Richard A. Kerr, *A Tempestuous Birth for Hurricane Climatology*, 312 SCIENCE 676 (May 5, 2006) [cited hereinafter as Kerr, *A Tempestuous Birth*].

[91] *See, e.g.*, Christopher W. Landsea, *Meteorology: Hurricanes and Global Warming*, 438 NATURE E11 (Dec. 22, 2005) (contending that "it is difficult to separate out any anthropogenic signal from the substantial natural multidecadal oscillations with a relatively short record of tropical-cyclone activity").

The cycle, which is driven by ocean currents that bring warm water into the Atlantic Ocean,[92] affects the number of hurricanes that form from tropical storms and causes hurricane activity in the North Atlantic to vary naturally over time.[93] The AMO involves shifts in factors other than SSTs that may affect hurricane activity, including vertical shear and mid-tropospheric moisture.[94] Other scientists have attributed recent increases in air and sea surface temperatures to still other causes, such as variations in solar activity.[95] A recent study concluded, however, that the sunspot cycle is unlikely to have had a significant impact on global temperatures since the seventeenth century.[96]

The line of demarcation between the adherents to the climate change and AMO hypotheses is not as stark as the foregoing discussion may seem to indicate. Few advocates of the climate change hypothesis discount the possibility that the AMO may be a factor in recent increases in hurricane intensity in the North Atlantic. One research team concluded, for example, that at least two-thirds of recent SST increases in the Atlantic and Pacific are linked to GHG emissions from human activities, necessarily implying that other factors are responsible for the remaining component.[97] Similarly, those who have trouble with the climate change hypothesis do not necessarily dispute the possibility that recent increased hurricane intensity in the North Atlantic is due to a combination of multidecadal scale changes in Atlantic SSTs, additional increases in those temperatures due to a long-term warming trend, and other natural factors.[98] One team of researchers concluded, for example, that rising SSTs no longer affect the intensity of a hurricane once its winds have reached speeds of more than 50 meters per second, making other aspects of the tropical environment critically important for tropical cyclone intensification.[99] The difference between the two opposing camps therefore may hinge

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But see Curry et al., *supra* note 53, at 1031 (arguing that "the trend in tropical SST cannot be explained by natural internal variability and/or volcanic eruptions or solar variability, and the observed trend is consistent with model simulations associated with forcing" from GHGs).

[92] Kerr, *Tempestuous Birth*, *supra* note 90.

[93] Trenberth, *Uncertainty in Hurricanes*, *supra* note 53. *Cf.* Webster et al., *supra* note 79 (contending that "strong interannual variability in hurricane statistics and the possible influence of interannual variability associated with El Niño and North Atlantic Oscillation make it difficult to discern any trend relative to background SST increases with statistical veracity").

[94] Webster et al., *supra* note 79. *See also* Curry et al., *supra* note 53, at 1030 (describing hurricanes as "complex dynamical systems whose intensities are affected by a variety of interactions between the storms, the underlying ocean, and the atmospheric environment, and physical processes internal to the storm").

[95] *See* Curry et al., *supra* note 53, at 1027.

[96] Peter Foukal et al., *Variations in Solar Luminosity and Their Effect on the Earth's Climate*, 443 NATURE 161 (Sept. 14, 2006) (finding "no evidence for solar luminosity variations of sufficient amplitude to drive significant climate variations on centennial, millennial and even million-year timescales"). The study's abstract adds that "[a]dditional climate forcing by changes in the Sun's output of ultraviolet light, and of magnetized plasmas, cannot be ruled out. The suggested mechanisms are, however, too complex to evaluate meaningfully at present." *Id*.

[97] Santer et al., *supra* note 52, at 13910.

[98] Goldenberg et al., *supra* note 52. *See also* Santer et al., *supra* note 52, at 13910 (suggesting that volcanoes also influence SST variability); Kerr, *Tempestuous Birth*, *supra* note 90 (quoting climate researcher who found persuasive arguments on both sides of the debate and who claimed that the "real story" is that scientists do not know which view is correct; "We don't know where we are in the middle.").

[99] P.J. Michaels et al., *Sea-Surface Temperatures and Tropical Cyclones in the Atlantic* Basin, 33 GEOPHYSICAL RESEARCH LETTERS GL025757 (May 10, 2006). At least one paper asserts that ocean spray at wind speeds over 40 meters per second may limit the degree to which future global warming will

on how scientists weight the impact of climate change and the AMO on past and future hurricane intensity.[100]

3. *Scientific Uncertainty, Hurricane Intensity, and Policy Responses*

The debate over the relationship between global climate change and hurricane activity is unlikely to reach a definitive resolution any time soon. Several proponents of the AMO hypothesis have predicted a forthcoming downturn in hurricane activity, and postulate that it may take more than a decade to determine whether predictions based on the AMO theory bear out.[101] Nevertheless, an editorial in the journal *Nature* asserted in June 2006 that "[i]n the past year, an emerging consensus has suggested that rising sea surface temperatures may well be causing hurricanes to become more intense over time."[102] The one thing that all scientists appear to agree on is the need for better data on climate and hurricane characteristics.[103]

The consequences for New Orleans and other low-lying areas from further storms of the magnitude of Hurricane Katrina are evident. Katrina was the costliest recorded weather catastrophe. It caused $125 billion in economic losses," of which only about $5 billion was insured through the private market. More than 1300 people died as a result of Katrina, and the hurricane displaced more than a million people from their homes, 250,000 of whom are not likely to return.[104] Louisiana was the only state in the country in which the gross state product declined in 2005.[105] It suffered a loss of five percent of state income for the year, a loss that amounts to a 15 percent loss for the post-hurricane months. The percentage loss was significantly greater in New Orleans and other coastal communities hit by the storm.[106]

One approach to any residual uncertainty would be to wait to take steps to combat global warming and the adverse effects on coastal communities that may be associated

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intensify tropical cyclones. *See* Lighthill, *Ocean Spray and the Thermodynamics of Tropical Cyclones*, 35 J. OF ENGINEERING MATHEMATICS 11 (1999). *See also* Philip J. Klotzbach, *Trends in Global Tropical Cyclone Activity Over the Past Twenty Years (1986–2005)*, 33 GEOPHYSICAL RESEARCH LETTERS L10805 (May 20, 2006) (contending that other important factors govern intensity and frequency of tropical cyclones besides SSTs).

[100] Moreover, the relative weights of the two factors is not necessarily the same in all circumstances.

[101] *See* Curry et al., *supra* note 53, at 1032 (adding that, "[i]n short, time will tell").

[102] *The Gathering Storm*, *supra* note 87. *See also id.* ("computer models suggest that the rise in intensity will be sufficient to cause concern."); Witze, *Tempers Flare*, *supra* note 81 (stating that "[p]reliminary studies by other groups seem to bear out" the findings of those, like Webster and Emanuel, who have detected a link between rising SSTs and more intense hurricanes in the North Atlantic); National Environmental Trust, *Hurricanes and Global Warming* (stating that "[t]he available scientific evidence indicates that it is likely that global warming will make — and possibly already is making — hurricanes stronger and more destructive"), *available at* http://www.net.org/proactive/newsroom/release.vtml?id=29104.

[103] *See, e.g.*, Curry et al, *supra* note 53, at 1029.

[104] STERN REVIEW, *supra* note 10, at 132.

[105] Frank Ackerman & Elizabeth Stanton, *Climate Change – The Costs of Inaction*, Report to Friends of the Earth England, Wales and Northern Ireland 3 (Oct. 11, 2006), *available at* http://www.ase.tufts.edu/gdae/policy_research/CostsofInaction.html.

[106] *Id*. at 4.

with it until the evidence of a link between a human-induced rise in global temperatures and increased hurricane intensity is overwhelming and beyond dispute. A more prudent approach is to treat the threat of increased storm activity as a serious one and act now to abate the threat, despite the uncertainty over whether increased hurricane ferocity is due primarily to naturally occurring oscillations in the ocean and pressure cycle, to rising air and water temperatures due to anthropogenic activities, or to some combination of the two. Deferring action until the evidence is clearer than some now perceive it to be is likely to make it more difficult and costly, if not impossible, to craft effective safeguards in the event that the postulated correlation between global warming and increased hurricane activity is clearly confirmed, even to the current skeptics.[107] As a *New Orleans Times-Picayune* editorial put it, "if hurricane development is heating up along with the planet, that should provide even more reason to finally start dealing with the problem."[108]

IV. THE FEDERAL GOVERNMENT'S RESPONSE TO THE THREAT OF GLOBAL CLIMATE CHANGE SINCE KATRINA

A wide variety of activities is capable of beneficially affecting global climate change. Individuals can reduce their contributions to global climate change by walking instead of driving or by turning down thermostats in the winter and turning them up in the summer. Businesses can commit voluntarily to the same kinds of energy-saving endeavors. Industrial emitters of the substances that contribute to global climate change can take the initiative to alter their production processes or install more effective control devices to achieve reductions in their emissions of GHGs. Given the scope and nature of the problem, however, it is unlikely that the United States will make meaningful progress in mitigating the ongoing and anticipated adverse effects of global climate change without government leadership, particularly by the federal government.[109] As a 2006 report to the British government put it, "[c]limate change is the greatest market failure the world has ever seen."[110]

If policymakers take seriously the threats to low-lying coastal areas in the Gulf Coast region and elsewhere in the United States that are posed by global warming, they must take steps that will result in meaningful reductions in the emission of GHGs such as

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[107] *Cf.* Climate Change Scientists Brief, *supra* note 8, at 13 (stating that, in the absence of GHG emission reductions, "[t]he anticipated sea level rise, especially when combined with likely increases in hurricane intensities, would exacerbate storm surges and have direct, negative impacts on health and welfare in the United States," with the effects concentrated in low-lying coastal regions).

[108] *Heat and Hurricanes*, NEW ORLEANS TIMES-PICAYUNE, June 24, 2006. *See also* Elsner, *supra* note 64, at 1 (arguing that the results of his study showing a correlation between global warming and increases in hurricane power "have serious implications for life and property throughout the Caribbean, Mexico, and portions of the United States").

[109] State and local governments have a significant role to play, too. Indeed, to date, those levels of government have been far more willing to tackle global climate change in meaningful fashion than the federal government has been. They have been at the forefront in adopting creative strategies to combat global climate change, acting in many cases to fill the vacuum created by the federal government's refusal to act. For a description of some of these state and local efforts, see Robert L. Glicksman, *From Cooperative to Inoperative Federalism: The Perverse Mutation of Environmental Law and Policy*, 41 WAKE FOREST L. REV. 719 (2006).

[110] STERN REVIEW, *supra* note 10, at viii.

carbon dioxide (CO_2). The principal source of CO_2 emissions is the burning of fossil fuels, and "[t]he international scientific consensus is clear that fossil fuel burning contributes to global warming, climate change, changing weather patterns, and threatens the world's environment."[111] Numerous strategies are available to accomplish reductions in GHG emissions.[112] The federal government, however, has pursued few if any of them. Indeed, the federal government is either committed to or considering policy options that would exacerbate the current contribution of GHG emissions in the United States to global climate change.[113]

The remainder of this Part first discusses a few of the policies that are designed to abate global climate change which the federal government might but thus far has chosen not to pursue. It next addresses some of the policies endorsed by the federal government in recent years that are likely to exacerbate the risks arising from global climate change discussed in Part III above. Together, these sins of omission and commission illustrate the federal government's regrettable lack of leadership on global climate change issues. The article next discusses some of the data that illuminate the potential costs of continued delays in the adoption of a proactive approach to combat human contributions to global warming as compared to the likely costs of abatement. Part IV concludes with preliminary discussion of the role of public opinion in shaping the government's response to the risks posed by global climate change, including increased coastal flooding and more intense hurricanes.

A. Sins of Omission

The federal government's failure to exercise available authority to pursue policies that show some promise to abate global climate change is reflected in its refusal to participate in the principal international agreement committing nations around the world to reduce GHG emissions. The federal Environmental Protection Agency (EPA)'s narrow reading of the scope of the Clean Air Act (CAA)[114] to justify its failure to regulate GHG emissions and to block state regulatory efforts of this kind represents another set of missed opportunities to attack global climate change at some of its apparent sources. Other regulatory strategies that the federal government has not pursued, or has failed to implement effectively, include raising the corporate average fuel economy standards applicable to manufacturers of new motor vehicles and requiring that electric utilities provide a certain percentage of the power they supply from alternative or nontraditional energy sources that generate fewer GHG emissions than energy derived from the combustion of fossil fuels.

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[111] Joseph P. Tomain, *Katrina's Energy Agenda*, 20-SPG. NAT. RESOURCES & ENV'T 43, 43 (2006) (quoting MIT Professor John M. Deutsch as stating "that the anthropogenic contribution to global warming is 'beyond reasonable scientific uncertainty'").

[112] *See generally* Cinnamon Carlarne, *Climate Change Policies An Ocean Apart: EU and US Climate Change Policies Compared*, 14 PENN. ST. ENVTL. L. REV. 435 (2006).

[113] The list of strategies discussed below is not meant to be exhaustive. Rather, the discussion is designed to illustrate the federal government's persistent failure to adopt effective policies for reducing GHG emissions and its lack of leadership in this area of environmental and energy policy.

[114] 42 U.S.C. §§ 7401-7671q.

1. *Participation in International Commitments to Reduce Greenhouse Gas Emissions*

One obvious mechanism for mitigating the risks that accompany increasing global temperatures involves committing the nation to a timetable for meaningful GHG emissions reductions. In December 1997, many nations, including the United States, participated in negotiations that culminated in the signing of the Kyoto Protocol, an agreement in which the industrialized nations agreed to reduce emissions of CO_2 and other GHGs by 2012.[115] After Russia became the 128th nation to ratify the treaty on November 18, 2004, the Kyoto Protocol entered into force on February 16, 2005.[116] The signatories to the Protocol account for more than 55 percent of the world's CO_2 emissions. Only four industrialized nations have not ratified the treaty: Australia, Liechtenstein, Monaco, and the United States (which by itself is responsible for about one quarter of total fossil fuel-derived CO_2 emissions).[117] President George W. Bush explained his continuing opposition to the treaty in early 2006, contending that cutting CO_2 emissions below 1990 levels "would have meant I would have presided over massive layoffs and economic destruction."[118]

2. *Unilateral Mandatory Emission Reduction Requirements*

Even if the United States harbors legitimate doubts about the approach to GHG reductions reflected in the Kyoto Protocol — whether these doubts are due to a fear of the potential adverse economic effects of the commitments demanded by the treaty or the potential inequities stemming from the treaty's failure to demand equal reductions by industrialized and developing countries — these concerns do not necessarily preclude unilateral action by the federal government to mandate reductions of air pollutants known to contribute to global climate change. For several years, however, EPA has steadfastly refused to adopt mandatory restrictions on emissions of CO_2 and other GHGs under the CAA, the obvious vehicle for imposing mandatory controls on emissions that contribute to global climate change. Even more perversely, EPA and the Justice Department have supported efforts to bar the states from taking similar actions.

EPA's position continues to be that it lacks the authority to regulate GHG emissions under the CAA. The agency and the Justice Department made that argument in *Massachusetts v. EPA*, a case decided by a three-judge panel of the Court of Appeals for the D.C. Circuit.[119] Twelve states, three cities, an American territory, and numerous

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[115] Kyoto Protocol to the United Nations Framework Convention on Climate Change, UN Doc. FCCC/CP/1997/L7/Add.1 (Dec. 10, 1997).
[116] See 36 Env't Rep. (BNA) 320 (2005).
[117] *See, e.g.*, Shari L. Diener, Note, *Ratification of Kyoto Aside: How International Law and Market Uncertainty Obviate the Current U.S. Approach to Climate Change Emissions*, 47 WM. & MARY L. REV. 2089, 2095 (2006) (citing Gregory B. Foote, *Considering Alternatives: The Case for Limiting CO_2 Emissions from New Power Plants Through New Source Review*, 34 ENVTL. L. REP. (ENVTL. LAW INST.) 10,642, 10,642 (July 2004)).
[118] News Release, *President Discusses Democracy in Iraq with Freedom House*, Mar. 30, 2006, *available at* http://www.whitehouse.gov/news/releases/2006/03/print/20060329-6.html.
[119] 415 F.3d 50 (D.C. Cir. 2005), *cert. granted*, 126 S. Ct. 2960 (2006).

environmental organizations appealed EPA's denial of a petition requesting that EPA regulate emissions of CO_2, methane, nitrous oxide, and hydrochlorofluorocarbons (HCFCs) from new motor vehicles under section 202(a)(1) of the Act.[120] EPA concluded that it did not have statutory authority to regulate GHG emissions from motor vehicles because those substances do not qualify as "air pollutants" for purposes of the CAA.[121] Even if they do, the Administration argued, the agency appropriately exercised its discretion in deciding not to regulate GHG emissions from motor vehicles "[u]ntil more is understood about the causes, extent and significance of climate change and the potential options for addressing it."[122]

Applying a deferential standard of judicial review, Judge Randolph concluded that the court need not address the scope of EPA's authority to regulate GHGs under the CAA because the policy judgments EPA made in deciding not to regulate GHG emissions did not amount to an abuse of its discretion. According to EPA, regulation of GHG emissions from motor vehicles under section 202(a)(1) would "result in an inefficient, piecemeal approach to the climate change issue" because new motor vehicles are only one of many sources of those emissions. The court also found no reason to dispute the legitimacy of the Administrator's concern that unilateral regulation of U.S. motor vehicle emissions might weaken efforts to persuade developing countries to take steps to reduce GHG emissions. EPA also justified its failure to act on the basis of ongoing research into scientific uncertainties and the agency's pursuit of programs to address climate change through voluntary emission reductions programs and agreements with private entities to develop new technology.[123] The Administration discounted the petitioners' suggestion that the federal government seek to reduce CO_2 emissions from motor vehicles by reducing gasoline consumption and improving tire performance. The federal Department of Transportation (DOT) had recently issued new fuel efficiency standards, which EPA asserted would result in significant reductions in CO_2 emissions. With respect to tire efficiency, EPA claimed that it likely lacked the power to regulate this aspect of motor vehicle performance under the CAA.[124] Judge Randolph felt compelled to uphold agency conclusions based on policy judgments such as those proffered by EPA whenever "an agency must resolve issues 'on the frontiers of scientific

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[120] Section 202(a)(1) authorizes EPA's Administrator to prescribe "standards applicable to the emission of any air pollutant from [motor vehicles] which in his judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare." 42 U.S.C. § 7521(a)(1).
[121] *Massachusetts v. EPA*, 415 F.3d at 53.
[122] *Id*. at 57.
[123] *See also* The White House, Council on Environmental Quality, *Addressing Global Climate Change* (stating that, "[t]hrough public-private partnerships, [President Bush] is working with businesses to encourage voluntary, cost-effective greenhouse gas emission reductions"), *available at* http://www.whitehouse.gov/ceq/global-change.html; EPA, *Climate Change – U.S. Climate Policy: National Goal to Reduce Emissions Intensity* (stressing voluntary programs to slow the growth of GHGs), *available at* http://www.epa.gov/climatechange/policy/intensitygoal.html; Julie Eilperin, *White House Outlines Global Warming Fight*, WASH. POST, Sept. 21, 2006 (describing the Bush Administration's reiteration of "its position that basic scientific research and voluntary actions can curb [GHGs] linked to climate change").
[124] *Massachusetts v. EPA*, 415 F.3d at 58.

knowledge.'"[125] The Supreme Court, which granted *certiorari* in the case in June 2006, will have an opportunity to address both the statutory authority and scope of discretion issues.[126]

It would be easier to take at face value the motivations advanced by EPA in the *Massachusetts* case if the executive branch supported efforts by the states to regulate GHG emissions, particularly CO_2 emissions from new motor vehicles. To the contrary, federal agencies have taken the position that, despite EPA's professed lack of authority to adopt mandatory controls on GHG emissions from motor vehicles under the CAA, any efforts by the states to step into the breach would violate the Supremacy Clause of the Constitution.[127] The National Highway Traffic Safety Administration (NHTSA), a part of the DOT, is responsible for establishing corporate average fuel economy (CAFE) standards pursuant to the Energy Policy and Conservation Act (EPCA).[128] It is NHTSA's stated position that any attempt by a state to regulate CO_2 emissions from new motor vehicles would be preempted by EPCA.[129] According to NHTSA, "a state may not impose a legal requirement relating to fuel economy, whether by statute, regulation or otherwise, that conflicts with this rule. A state law that seeks to reduce motor vehicle carbon dioxide emissions is both expressly and impliedly preempted."[130]

The federal government has gone one step further. The automobile industry has filed suit in federal court contesting California's authority to adopt controls on CO_2 emissions from automobiles on the ground that state regulatory efforts are preempted by

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[125] *Id*. (quoting Environmental Def. Fund v. EPA, 598 F.2d 62, 82 (D.C. Cir. 1978)). Judge Sentelle concluded that the plaintiffs lacked standing, but concurred in the judgment reached by Judge Randolph, stating that he was willing to "accept [Judge Randolph's decision] as dictating the law of this case." *Id*. at 61 (Sentelle, J., dissenting in part and concurring in the judgment). Judge Tatel wrote a vigorous dissent, arguing that EPA does have the authority to regulate CO_2 emissions under § 202(a)(1) and that EPA abused its discretion in denying the petition requesting that it do so. *Id*. at 61-80 (Tatel, J., dissenting).

[126] Massachusetts v. EPA, 126 S. Ct. 2690 (2006).

[127] U.S. CONST. art. VI, cl. 2.

[128] Energy Policy and Conservation Act, Pub. L. No. 94-163, § 301, 89 Stat. 871 (1975) (codified as amended at 49 U.S.C. §§ 32906-32919).

[129] ECPA provides that "[w]hen an average fuel economy standard prescribed under this chapter is in effect, a State or a political subdivision of a State may not adopt or enforce a law or regulation related to fuel economy standards or average fuel economy standards for automobiles covered by an average fuel economy standard under [EPCA]"). 49 U.S.C. § 32919(a).

[130] Average Fuel Economy Standards for Light Trucks; Model Years 2008-2011; Notice of Proposed Rulemaking, 70 Fed. Reg. 51,414, 51,457 (2005). The preamble to the notice of proposed rulemaking provided NHTSA's first official expression of its opinion on the preemptive effect of EPCA on state regulatory authority over CO_2 emissions. NHTSA confirmed its position when it issued the final CAFE standards, stating that "[i]n response to the public comments and letters from members of Congress, we have re-analyzed all issues carefully . . . and determined, based on existing and foreseeable technologies for reducing CO_2 emissions from motor vehicles, that the effect under EPCA and the Supremacy Clause of the U.S. Constitution is that State regulation of those emissions is preempted." Average Fuel Economy Standards for Light Trucks Model Years 2008-2011, 71 Fed. Reg. 17,566, 17,657 (2006). *See also id*. at 17,667 (stating that California's motor vehicle "greenhouse gas regulation is, therefore, clearly related to fuel economy standards and thus subject to the preemption provision in EPCA"). According to NHTSA, California's regulatory authority is both explicitly and implicitly preempted by EPCA. *Id*.

EPCA.[131] NHTSA itself has described the federal government's participation in this quest to oust the states of their regulatory authority to attack global climate change through the imposition of controls on motor vehicle emissions of CO_2:

> In October 2002, the United States filed an amicus curiae brief in support of affirming the [district court's June 2002 order issuing a preliminary injunction prohibiting the state from implementing its controls] in Central Valley Chrysler-Plymouth, Inc. et al. v. Michael P. Kenny, No. 02-16395, (9th Cir. 2002), pointing out that EPCA contains a broadly stated provision expressly preempting state regulations "related to" fuel economy standards. The government further pointed out that, unlike the Clean Air Act, EPCA does not contain an exception allowing a state law that regulates fuel economy, regardless of the purpose of the law.[132]

The federal executive branch has thus not been satisfied by the vigorous defense of its own refusal to regulate CO_2 emissions under the CAA. It also has stoked industry's efforts to bar the states from engaging in the regulatory efforts that the federal government has foresworn.

3. *Corporate Average Fuel Economy Standards*

One way for the government to spur reductions in GHG emissions would be to impose mandatory restrictions on both mobile and stationary source emissions. The federal government has long refused thus far to pursue that path, and, perhaps even more perversely, has recently placed obstacles in the way of state governments that have chosen to do so. Alternatively, the federal government could engage in efforts to reduce fossil fuel consumption, the primary source of GHG emissions. Unfortunately, the federal government's track record in this regard is also rather dismal.

As the discussion above of the *Massachusetts* case indicates, one of the federal government's justifications for refusing to regulate GHG emissions from new motor vehicles under the CAA has been the actions NHTSA has taken to reduce CO_2 emissions through revisions to the CAFE standards under EPCA.[133] The impression one might get from EPA's reliance on NHTSA's implementation of EPCA as a reason not to restrict CO_2 emissions under the CAA is that the federal government has pressed the automobile

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[131] Central Valley Chrysler-Plymouth v. California Air Resources Bd., No. CV-F-02-5017 REC/SMS, 2002 U.S. Dist. LEXIS 20403 (E.D. Cal. June 11, 2002) (enjoining California zero-emission-vehicle rule).

[132] 71 Fed. Reg. at 17,568. Industry has also attacked the validity of state efforts to regulate CO_2 emissions from motor vehicles on the ground that such regulation is preempted by the CAA, notwithstanding EPA's refusal to regulate (and professed lack of authority to regulate) those emissions. In Central Valley Chrysler-Jeep Inc. v. Witherspoon, 2006 WL 2734359 (E.D. Cal. Sept. 25, 2006), the court denied California's motion for judgment on the pleadings, holding that industry stated a claim for preemption of the state's regulations restricting CO_2 emissions from motor vehicles under both EPCA and the CAA. The court granted the state's motion for judgment on the pleadings on the issue of whether the regulations violated the dormant Commerce Clause. *Id*. at *21.

[133] *See supra* notes 127-30 and accompanying text. The CAFE standards reflect "the sales weighted average fuel economy, expressed in miles per gallon (mpg), of a manufacturer's fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 lbs. or less, manufactured for sale in the United States, for any given model year." NHTSA, *CAFE Overview — Frequently Asked Questions*, *available at* http://www.nhtsa.dot.gov/cars/rules/cafe/overview.htm [hereinafter *CAFE Overview*].

industry to facilitate reduced fossil-fuel consumption by the driving public through mandated improvements in the fuel efficiency of the vehicles it produces.[134]

Such an impression would not accurately reflect reality. NHTSA issued final regulations in April 2006 that phased in higher CAFE standards for model year (MY) 2008-2011 light trucks.[135] The 2006 revisions phased in an increase in the standards for light-duty trucks from 22.2 miles per gallon (mpg) to 23.5 mpg.[136] NHTSA estimated that the new standards will save approximately 7.8 billion gallons of fuel over the lifetime of the vehicles sold during the four model years covered by the standards.[137]

Neither Congress nor NHTSA has increased the CAFE standards for passenger automobiles, however, since 1986, when the standards were set for MY1990 vehicles at 27.5 mpg.[138] Beginning in 1996, Congress adopted a series of appropriations riders that prohibited NHTSA from increasing CAFE standards for either passenger cars or light-duty trucks.[139] While the CAFE standard for passenger vehicles has remained fixed at 27.5 mpg, overall fuel economy in the United States has actually declined.[140] This decline has resulted from the growth in the market share of light trucks, which were and continue to be subject to lower CAFE standards.[141] According to a recent House Subcommittee staff report,

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[134] Some observers, however, have characterized efforts to attack global warming through the establishment of minor increases in the CAFE standards as "ineffective Potomac incrementalism." *See* Zygmunt J.B. Plater, *Dealing with Dumb and Dumber: The Continuing Mission of Citizen Environmentalism*, 20 J. ENVTL. L. & LITIG. 9, 62 (2005) (citing Michael Shellenberger & Ted Nordhaus, *The Death of Environmentalism* 10 (2004), *available at* http://www2.bc.edu/%7Eplater/Newpublicsite05/02.9.pdf).

[135] Fuel Economy Standards for Light Trucks Model Years 2008-2011; Final Rule, 71 Fed. Reg. 17,566 (2006).

[136] *Id*. at 17,566. NHTSA had previously increased the CAFE standards for light trucks from 20.7 to 22.2 mpg in 2003. Light Truck Average Fuel Economy Standards Model Years 2005-2007; Final Rule, 68 Fed. Reg. 16,868 (2003).

[137] 71 Fed. Reg. at 17,569.

[138] Reforming the Automobile Fuel Economy Standards Program; Advanced Notice of Proposed Rulemaking, 68 Fed. Reg. 74,907, 74,909 (2003); Office of Automotive Affairs, *"CAFE," available at* http:// www.ita.doc.gov/td/auto/cafe.html; *CAFE Overview*, *supra* note 133. *See also* Robert B. McKinstry, Jr., *Laboratories for Local Solutions for Global Problems: State, Local, and Private Leadership in Developing Strategies to Mitigate the Causes and Effects of Climate Change*, 12 PENN. ST. ENVTL. L. REV. 15, 25 (2004) (criticizing Congress for its failure to revise the CAFE standards, despite increases in the number of vehicle miles traveled).

[139] 68 Fed. Reg. at 16,868. *See, e.g.*, Pub. L. 104-50, § 330, 109 Stat. 436 (1995) (providing that "[n]one of the funds in this Act shall be available to prepare, propose, or promulgate any regulations pursuant to title V of the Motor Vehicle Information and Cost Savings Act (49 U.S.C. 32901, et seq.) prescribing corporate average fuel economy standards for automobiles, as defined in such title, in any model year that differs from standards promulgated for such automobiles prior to enactment of this section"). In July 2001, Secretary of Transportation Norman Mineta requested that Congress not renew the appropriations riders. Congress omitted the riders from the Department of Transportation and Related Agencies Appropriations Act for FY 2002, Pub. L. 107-87, 115 Stat. 833 (2001). *See* 68 Fed. Reg. at 16,868. The appropriations prohibition was lifted effective December 18, 1001. *See CAFE Overview*, *supra* note 133.

[140] *See* Kriz, *supra* note 3, at 23-24 (stating that, "according to EPA, passenger vehicles are no more efficient than they were in the early 1990s, and they're less efficient than they were in the late 1980s").

[141] *See* Kyler Smart, Note, *Losing Ground: How SUVs Are Making the United States Less Fuel-Efficient and Options for Reversing the Downward Trend*, 7 ENVTL. L. 159, 159 (2000).

> Fuel economy has stagnated since 1985, greatly contributing to US oil dependence since the transportation sector consumes the bulk of oil. US industry found it easier to lobby against CAFE increases as an impediment to business operations than to keep making strides in fuel efficiency. . . . [T]he government must reassess its role in preventing shocks to US industry by enhancing efficiency rather than myopic policies protecting the status quo. . . .
>
> . . . Higher mileage requirements are achievable and cost-effective. Increases in CAFE standards will ultimately make US automakers more — not less — competitive.[142]

The Bush Administration deserves credit for its role in the termination of the appropriations freeze on increases in the CAFE standards and for the incremental increases in the standards for light trucks in 2003 and 2006. A much more aggressive approach is needed, however, both for passenger cars and larger vehicles such as sport utility vehicles and pick-up trucks. Two bills introduced in the House of Representatives during the 109th Congress would require NHTSA to increase the CAFE standard for automobiles (including passenger cars) to 33 mpg by MY 2015.[143] A more ambitious Senate bill introduced in 2005 would phase in more stringent fuel economy standards, reaching 40 mpg for passenger cars and 27.5 mpg for all other vehicles beginning with MY 2016 vehicles.[144] If the United States had begun in 2001 a ten-year phase-in of a 40 mpg standard, by mid-2006, Americans would have saved 267 billion barrels of oil each year (almost twice the amount produced each year at the Prudhoe Bay field in Alaska).[145] The Senate bill would also expand the number of vehicles subject to the CAFE standards for passenger automobiles by expanding the definition of that term, leaving fewer vehicles subject to the less stringent standards for larger vehicles.[146] Even a modest four percent increase in the CAFE standards annually would save an estimated 1.3 million barrels of oil per day and twenty billion gallons of gasoline each year.[147] As of this writing, however, none of these bills has even been reported out of committee.

4. *Renewable Portfolio Standards*

Proponents of the exercise of federal regulatory authority to combat human contributions to global climate change have suggested that the federal government require electric utilities to distribute a certain percentage of the electricity they supply to their customers through the use of renewable resources as a means of reducing the

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[142] Majority Staff Report to Comm. on Gov't Reform Chairman Tom Davis and Subcomm. on Energy and Resources Chairman Darrell E. Issa, Comm. on Gov't Reform, U.S. House of Representatives, *Securing America's Energy Future* 21-22 (May 8, 2006). The report suggests the use of tradable credits to maximize efficiency in achieving fuel economy. *Id*. at 22.

[143] H.R. 5543, 109th Cong., 2d Sess. (2006); H.R. 3762, 109th Cong., 1st Sess. (2005).

[144] S. 1648, § 2, 109th Cong., 1st Sess. (2005). The bill would permit the Secretary of DOT to avoid the last step of the increase for vehicles other than passenger cars by submitting to Congress a report explaining the reasons for not increasing the standard. *Id*. § 2(b)(3).

[145] *See Lessons From Prudhoe Bay*, N.Y. TIMES, Aug. 9, 2006, at A20 (editorial). Even if cars and trucks in the U.S. improved fuel economy by only one mpg, the savings would exceed 400,000 barrels of oil each day. *See* Union of Concerned Scientists, *BP Pipeline Shutdown Highlights Nation's Oil Dependence* (Aug. 7, 2006), *available at* http://www.ucsusa.org/news/press_release/bp-pipeline-shutdown.html.

[146] S. 1648, § 3, 109th Cong., 1st Sess. (2005).

[147] Center for American Progress Action Fund, *The Progress Report* (July 26, 2006).

combustion of fossil fuels that generate emissions of GHGs such as CO_2.[148] Such a requirement might take the form of what has been called a renewable portfolio standard (RPS). A RPS is "a market-based strategy[149] to ensure that renewable energy constitutes a certain percentage of total energy generation or consumption. An RPS operates through government regulations requiring electricity generators or sellers to supply a percentage of their electricity generation or sales with electricity from renewable energy sources by specified dates."[150] Because renewable resources and technologies are often not cost competitive with traditional resources, RPS programs may be accompanied by the provision of subsidies and financial incentives to encourage the development and use of these cleaner resources and technologies.[151]

At least twenty states have adopted their own RPSs,[152] and some have even considered regional RPSs.[153] Some foreign nations have created similar programs.[154] Legislators introduced bills that would have created a federal RPS program as early as 1997, and the Clinton Administration sponsored such legislation in 1998, but none of those bills was adopted.[155] Similar legislation, much of it introduced or supported by the Clinton Administration, failed to pass muster during the period 1999-2000.[156]

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[148] *Cf.* Center for Progressive Reform, *An Unnatural Disaster: The Aftermath of Hurricane Katrina* 23 (Sept. 2005) (inquiring whether the federal government should follow the lead of several states in imposing such requirements). *See also* Jason R. Wiener, *Sharing Potential and the Potential for Sharing: Open Source Licensing as a Legal and Economic Modality for the Dissemination of Renewable Energy Technology*, 18 GEO. INT'L ENVTL. L. REV. 277, 295 n.84 (2006) (stating that "[g]overnment instruments to incentivize renewable energy development may include: renewable energy tax credits; federal ethanol incentives; private sector project finance participation; and promulgation of renewable portfolio standards").

[149] The RPS is sometimes described as a market-based strategy because "it is usually accompanied by a credit trading mechanism. It thus provides flexibility to electric utilities in complying with the standard requirement and rewards the most efficient, price-competitive renewable energy technologies." Inho Choi, *Global Climate Change and the Use of Economic Approaches: The Ideal Design Features of Domestic Greenhouse Gas Emissions Trading with an Analysis of the European Union's CO_2 Emissions Trading Directive and the Climate Stewardship Act*, 45 NAT. RES. J. 865, 934 n.308 (2005).

[150] Tomain, *supra* note 111, at 47.

[151] *See* Sidney A. Shapiro & Joseph P. Tomain, *Rethinking Reform of Electricity Markets*, 40 WAKE FOREST L. REV. 497, 524-25 (2005).

[152] Edna Sussman, *New York Addresses Climate Change with the First Mandatory Greenhouse Gas Program*, 78 N.Y. ST. B.J. 43, 48 (May 2006) (citing Pew Center on Global Climate Change, State Activities, http:// www.pewclimate.org/policy_center/policy_maker_s_guide/state_ activities/index.cfm); Tomain, *supra* note 111, at 47 (noting that California and Maine have adopted RPS programs). James W. Moeller, *Of Credits and Quotas: Federal Tax Incentives for Renewable Resources, State Renewable Portfolio Standards, and the Evolution of Proposals for a Federal Renewable Portfolio Standard*, 15 FORDHAM ENVTL. L. REV. 69, 97-131 (2004), describes a variety of state RPS programs.

[153] *See* Adam Rose et al., *Regional Carbon Dioxide Trading in the United States: Coalition Choices for Pennsylvania*, 14 PENN. ST. ENVTL. L. REV. 203, 209 (2006).

[154] *See* Carlarne, *supra* note 12, at 442 (United Kingdom).

[155] Moeller, *supra* note 152, at 131-42. At the request of a congressional subcommittee, the CRS analyzed the constitutionality of a federal RPS program. It concluded that the U.S. Constitution "permit[s] the states to regulate the sale and distribution of electric power in accordance with federal dictates. According to the CRS, '[g]enerally speaking, if states are given a choice about whether to regulate, the legislation is permissible (under the U.S. Constitution). If, however, states are required to regulate according to federal standards, the legislation is unconstitutional.'" *Id.* at 139.

[156] *See* Moeller, *supra* note 111, at 132-42.

In early 2005, during the process that culminated in the enactment of the Energy Policy Act of 2005 (EPAct 2005),[157] the Senate passed a bill that included a federal RPS program. The program would have mandated that a portion of electricity generation be derived from solar, wind, ocean, or geothermal energy, biomass, landfill gas, generation offsets, or incremental hydropower. That mandate would have been phased in, beginning at one percent of national generation in 2005, then increasing by about one and a half percent each year until reaching the goal of twenty percent by 2020.[158] The Bush Administration, however, "strongly opposed the RPS," and it was struck from EPAct 2005 in committee and excluded from the adopted version of the legislation.[159] When Congress finally passed the massive EPAct 2005, it did not include provisions creating a RPS program. Legislators have since reintroduced bills containing federal RPS mandates,[160] but none has been adopted at this writing. As a result, to date there are no federal RPS programs.[161]

B. Sins of Commission

In some instances, the federal government's policies have not merely consisted of failing to pursue initiatives that hold promise as means to mitigate the anticipated adverse effects of global warming. Instead, those policies have consisted of efforts to enable and promote the very kinds of activities most likely to generate additional GHG emissions. The persistent efforts by the White House to convince Congress to authorize oil and gas exploration and development activities in the Arctic National Wildlife Refuge provide an obvious example of the federal government's emphasis on continued reliance on fossil fuels as the core component of the nation's energy strategy.[162] It is obviously necessary to include fossil fuel use as a component of any national energy strategy. But federal energy policy need not rely primarily on the fuels that generate the highest levels of GHG emissions, particularly in the long run.

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[157] Pub. L. No. 109-58, 119 Stat. 594.

[158] Energy and Resources Comm., *Renewable Energy Resources*, *in* ABA ENVIRONMENT, ENERGY, AND RESOURCES LAW: THE YEAR IN REVIEW 2005, at 280.

[159] *Id*.

[160] *E.g.*, H.R. 983, 109th Cong., 1st Sess. (2005) (introduced by Rep. Tom Udall) (phasing in increasing "required annual percentage of the retail electric supplier's base amount that shall be generated from renewable energy resources" up to 20% beginning in 2027); S. 2747, § 610, 109th Cong., 2d Sess. (2006) (introduced by Sen. Jeff Binghaman) (phase-in of 10% RPS mandate by 2020); H.R. 5331, 109th Cong., 2d Sess. (2006) (introduced by Rep. Pomeroy) (same).

[161] *Cf.* Joel B. Eisen, *The Environmental Responsibility of the Regionalizing Electric Utility Industry*, 15 DUKE ENVTL. L. & POL'Y F. 295, 306 (2005) (noting that Congress "has been slow to take to the notion of a federal renewable portfolio standard"). Senator Norm Coleman of Minnesota reportedly was considering the introduction in late 2006 of a bill that would establish a national RPS program, but that would also prohibit EPA from regulating CO_2 emissions and preempt state regulation of such emissions. Avery Palmer & Dawn Reeves, *GOP Senator, Utility Back Plan Blocking EPA, State Rules on CO2*, INSIDE E.P.A., Oct. 20, 2006, at 1. The proposal would also seek to promote nuclear power production. *Id*. at 14.

[162] *See, e.g.*, Elizabeth Chalecki, *The New Petro-Military*, 30 FLETCHER F. WORLD AFF. 239, 241 (Winter 2006) (reviewing MICHAEL T. CLARE, BLOOD AND OIL: THE DANGERS AND CONSEQUENCES OF AMERICA'S GROWING DEPENDENCY ON IMPORTED PETROLEUM (2004)).

A good example of the federal government's continued, persistent emphasis on a fossil fuel-based energy policy is EPAct 2005. That statute "promotes development largely along traditional lines," focusing the most attention on promoting the development of electricity dependent on the use of coal, oil, and natural gas, although the Act also seeks to promote hydropower and nuclear power, and does not completely ignore either renewable resources or conservation.[163] Among the objectives of EPAct 2005 are enhanced coal leasing and oil and gas leasing and permitting on federal lands through techniques such as providing royalty incentives and tax credits to the oil and natural gas industries. The Act also addresses less traditional energy options, including the development of oil shale and tar sands and the creation of monetary incentives to increase the development of renewable energy resources such as solar, wind, biomass, and geothermal energy.[164]

EPAct 2005 has been characterized as "a continuation of traditional energy policy by paying the most attention to incumbent energy producers," with "the bulk of the Act favor[ing] traditional industries."[165] By one accounting, the statute provides more than $4 billion to the oil industry, $3 billion to the coal industry, and more than $5 billion to the nuclear power industry. EPAct 2005 makes $11.6 billion in taxpayer subsidies available to oil and utility companies.[166] The Act's critics assert that "EPAct 2005, like the energy legislation that went before it, fails to coordinate U.S. energy policy and simply continues the historic policy of favoring large-scale, capital-intensive fossil fuel energy industries with a tip of the hat to alternative policies and new competitors."[167]

The federal government's continued emphasis on fossil fuel-based energy development is not inevitable. Energy law and policy experts such as Professor Joseph Tomain have urged a shift toward alternative sources of energy. Such a shift would not only decrease the country's reliance on precarious sources of foreign oil. It also would have the benefit of moving toward an economy that runs on fuels that generate fewer pollutants that contribute to global climate change.[168]

> A "smart energy" policy involves reducing our increasing use of fossil fuels, facilitating the development of new market entrants, encouraging the use of advanced technologies in energy industries, and increasing use of alternative and renewable fuels. These goals can be achieved by establishing proper regulatory standards and by shifting subsidies and

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[163] Tomain, *supra* note 111, at 45.
[164] *Id*. (also noting that the statute "requires the use of renewable resources in federal buildings" and "provides increased energy efficiency standards for certain facilities and appliances and provides financial support for unconventional energy sources such as hydrogen, fusion, and fuel cell technologies").
[165] *Id*.
[166] *Id*. at 45-46.
[167] *Id*. at 46.
[168] To some observers, the nuclear power option has become more attractive than it has been during the last couple of decades because nuclear plants do not generate GHG emissions. *See, e.g.*, Christopher R. Chandler, *Recent Developments in Licensing and Regulation at the Nuclear Regulatory Commission*, 58 ADMIN. L. REV. 485, 485-86 & n.3 (2006); Cass Sunstein, *Irreversible and Catastrophic*, 91 CORNELL L. REV. 841, 862 (2006); Kriz, *supra* note 3, at 22 (noting that more than two dozen nuclear power plants are in the planning stages in the U.S.).

> tax incentives away from financially stable incumbent firms to emerging market entrants as a means of increasing competition rather than maintaining the status quo. . . . .
>
> Smart energy relies on small-scale, decentralized, technologically sophisticated, clean, renewable energy production offering alternatives to large-scale, centralized, brute force, dirty, fossil fuels. Regarding fossil fuel alternatives, biofuels, for example, are useful additives to gasoline, thus stretching our oil supply. Conservation through mileage standards, carbon taxes and emissions programs can reduce consumption and increase fuel efficiency.[169]

Other potential contributions to an energy policy that serves to decrease reliance on the use of fossil fuels that contribute to global climate change include "technological advances to the internal combustion engine, hybrid car designs, and new automobile fuels to reduce fossil fuel consumption. Clean coal technologies such as coal gasification and carbon capture can also improve energy efficiency and reduce emissions of greenhouse gases."[170]

Critics of EPAct 2005's failure to shift the nation's energy policy toward less environmentally damaging sources of energy have sought to redress the imbalance they perceive in the government's treatment of traditional and alternative fuel sources. Legislators in the House of Representatives introduced a bill in late 2005 called the Clean Alternatives for Energy Independence Act of 2005, whose stated purpose was to "repeal tax subsidies for oil and gas enacted by the Energy Policy Act of 2005 and to use the proceeds to double certain alternative energy incentives provided for in such Act."[171] As this article was being prepared, the bill seemed to have died in the House Committee on Ways and Means despite bipartisan sponsorship. Meanwhile, the House of Representatives passed a bill in 2006 that would terminate a 25-year moratorium on drilling for offshore oil and gas along both the Atlantic and Pacific Coasts.[172] The Senate

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[169] Tomain, *supra* note 111, at 46-47.

[170] *Id*. at 47. Professor Tomain also points to "distributed energy" (DG) as an example of a strategy for moving away from reliance on fossil fuel-derived energy production. DG "promises alternative electricity generation that focuses on nonutility, small-scale power production. The core concept behind DG is that power will be produced locally by smaller producers relying on a variety of energy sources and technologies, such as solar cells and wind turbines." *Id*.

[171] H.R. 4623, 109th Cong. 1st Sess. (2005).

[172] H.R. 4761, 109th Cong., 1st Sess. (2006). Among the stated policies of the "Deep Ocean Energy Resources Act of 2006" are the following:

- "the United States is blessed with abundant energy resources on the outer Continental Shelf and has developed a comprehensive framework of environmental laws and regulations and fostered the development of state-of-the-art technology that allows for the responsible development of these resources for the benefit of its citizenry;"
- "the existing laws governing the leasing and production of the mineral resources of the outer Continental Shelf have reduced the production of mineral resources, have preempted Adjacent States from being sufficiently involved in the decisions regarding the allowance of mineral resource development, and have been harmful to the national interest;" and
- "the national interest is served by granting the Adjacent States more options related to whether or not mineral leasing should occur in the outer Continental Shelf within their Adjacent Zones."

Id. § 2. *See also* H.R. Rep. 109-531 (2006). The bill passed by the House would allow oil and natural gas production within 100 miles of the U.S. coastline, and between 50 and 100 miles of a state's coast unless a coastal state chooses to opt out. Darren Goode, *Dueling Over Drilling*, NAT'L J., Aug. 5, 2006, at 40, 41.

enacted a similar measure in August 2006, although its version of the bill would authorize offshore drilling in a narrower area and would retain more restrictions on drilling than the House-passed version would.[173] The House and Senate adjourned for the 2006 mid-term elections without reconciling the two bills.[174]

In short, events subsequent to the enactment of EPAct 2005 reflect some interest among federal policymakers in redressing the imbalance in favor of continued development and use of fossil fuels that is reflected in long-standing federal energy policy, but not enough to shift the country toward a policy that is designed to significantly reduce reliance on energy sources that contribute to global climate change.

C. The Costs of Doing Nothing (or Next to Nothing)

The effects of global climate change on sea levels and hurricane intensity represent but a small part of the predicted adverse effects of unabated release of GHGs. A report to the British government in 2006 asserts that "[c]limate change will affect the basic elements of life for people around the world – access to water, food production, health,[175] and the environment. Hundreds of millions of people could suffer hunger, water shortages and coastal flooding as the world warms."[176] The report adds that "[o]ur actions now and over the coming years could create risks of major disruption to economic and social activity, on a scale similar to those associated with the great wars and the economic depression of the first half of the 20th century. And it will be difficult or impossible to reverse these changes."[177] "If emissions continue unabated," the report indicates, "the world will experience a radical transformation of its climate," with "profound implications . . . for our way of life."[178] If assessments such as this one are accurate, the stakes of combating global climate change or failing to do so are extraordinarily high.

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[173] S. 3711, 109th Cong., 2d Sess. (2006), the "Gulf of Mexico Energy Security Act of 2006," passed by a vote of 75-21, on August 1, 2006. *See* http://thomas.loc.gov/cgi-bin/bdquery/z?d109:s.03711. The bill would open 8.3 million acres in the central Gulf of Mexico, an area believed to contain 1.2 billion barrels of oil and about six trillion cubic feet of natural gas, to oil and gas drilling. *See* Clifford Kraus, *Senate Bill Lifts Hopes of Big Offshore Oil*, N.Y. TIMES, Aug. 3, 2006, at C1. *See also* Steven Mufson & Jonathan Weisman, *Congressional Interest in Energy Bills Dims*, WASH. POST, July 25, 2006, at A13; Zachary Colie, *Senate to Debate Drilling for Oil, Gas; GOP Bill Backers Stress Energy-Cost Savings, but Foes Worry About Potential Harm to Coast*, S.F. CHRONICLE, July 24, 2006; *Drain America First*, N.Y. TIMES, July 25, 2006 (editorial). The bill would restrict drilling within 235 miles of Florida's west coast and 125 miles of its panhandle. *Senate Passes Offshore Drilling Bill; Democratic Filibuster Threat Remains*, 37 ENV'T REP. (BNA) 1634 (Aug. 4, 2006).

[174] Lynn Gardner, *Offshore Drilling Deal Proves Elusive; Congress Will Try Again in Lame Duck*, 37 ENV'T REP. (BNA) 2051 (Oct. 6, 2006).

[175] Climate change, for example, is projected to increase deaths from malnutrition, heat stress, and infectious diseases such as malaria and dengue fever. STERN REVIEW, *supra* note 10, at 74.

[176] *Id*. at vi. *See also id*. at 56 (asserting that "[c]limate change threatens the basic elements of life for people around the world – access to water, food, health, and use of land and the environment").

[177] *Id*. at vi.

[178] *Id*. at 17. The report makes it clear, however, that the impacts will differ according to location and economic situation. Generally, for example, "developed countries will be less vulnerable to climate change" than developing countries. *Id*. at 122.

But efforts to address global climate change through regulatory actions of the kind described in the preceding two sections obviously will be costly. Some have argued that because the nature and magnitude of the effects of global climate change have not yet come into focus, it makes sense to defer costly regulation until the picture is clearer so that abatement expenditures are not wasted or misallocated. As one editorial write put it, "we need to balance uncertain future benefits against certain costs today. Most steps to combat global warming will be expensive and will slow economic growth, inevitably affecting poor people around the world."[179]

This is not the place to engage in a full-fledged review of the respective advantages and disadvantages of the kind of cost-benefit analysis (CBA) suggested by this quotation as a means of settling on governmental policy toward the health, safety, and environmental threats posed by global climate change. The literature criticizing the application of economic analysis and theory in general, and the use of CBA in particular, to solve environmental problems is extensive.[180] Professor Douglas Kysar has raised serious concerns about the use of CBA in shaping policy responses to the potential adverse effects of global climate change.[181] Professor Kysar does not oppose "efforts to identify the expected consequences of climate change or of proposals to mitigate or adapt to climate change. There are obvious and sound reasons for wanting to know, with as much precision as is feasible at a given moment, what the likely positive and negative effects of engaging in a particular course of action are in response to an impending problem."[182] He does argue, however, that CBA should not be used "to determine the content of climate change policy goals, rather than merely the method by which those goals are implemented."[183] Professor Kysar identifies

> four key limitations of the use of CBA in the climate change context: (1) the inconsistency between CBA's problem-state assumptions and the actual level and nature of uncertainty surrounding climate change; (2) the inability of the valuation methodologies utilized by CBA practitioners to consider appropriately the

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[179] John Tierney, *The Kids Are All Right*, N.Y. TIMES, Oct. 14, 2006, at A23.

[180] *See, e.g.*, FRANK ACKERMAN & LISA HEINZERLING, PRICELESS: ON KNOWING THE PRICE OF EVERYTHING AND THE VALUE OF NOTHING (2004); Frank Ackerman & Lisa Heinzerling, *Pricing the Priceless: Cost-Benefit Analysis of Environmental Protection*, 150 U. PA. L. REV. 1553 (2002); David Driesen, *Is Cost-Benefit Analysis Neutral?*, 77 COLO. L. REV. 335 (2006); David Driesen, *Distributing the Costs of Environmental, Health and Safety Protection: The Feasibility Principle, Cost-Benefit Analysis, and Regulatory Reform*, 32 B.C. ENVTL. AFF. L. REV. 1 (2005) Thomas O. McGarity, *A Cost-Benefit State*, 50 ADMIN. L. REV. 7 (1998).

[181] Professor Kysar defines cost-benefit analysis as a "policymaking paradigm" that "strives to enhance social welfare by predicting, weighting, and aggregating all relevant consequences of policy proposals in order to identify those choices that represent welfare-maximizing uses of public resources." Douglas A. Kysar, *It Might Have Been: Risk, Precaution, and Opportunity Costs*, Cornell Law School, Legal Studies Research Paper Series, Research Paper No. 06-023, *available at* http://ssrn.com/asbtract=927995 [hereinafter Kysar, *Opportunity Costs*].

[182] Douglas A. Kysar, *Climate Change, Cultural Transformation, and Comprehensive Rationality*, 31 B.C. ENVTL. AFF. L. REV. 555, 557 (2004) [hereinafter Kysar, *Climate Change*].

[183] *Id*. Economic analysis can be used to make sure that the method chosen for achieving a goal identified through methods other than CBA are achieved in the most cost-effective manner. *See* SIDNEY A. SHAPIRO & ROBERT L. GLICKSMAN, RISK REGULATION AT RISK: RESTORING A PRAGMATIC APPROACH 136-37 (2003).

> anticipated losses of human life and environmental resources; (3) the impropriety of using exponential discounting within CBA to resolve decisions regarding the intertemporal distribution of costs and benefits; and (4) the inherent orientation of CBA toward the status quo, or what David Driesen would call its static, rather than dynamic, efficiency orientation. Together, these limitations suggest that CBA is an unacceptably crude device for guiding policy choices in the context of a massively complex and morally imbued problem such as global climate change.[184]

He elaborates on the fourth point as follows:

> The deeper problem is that the neoclassical economic project, as exemplified by CBA, excludes from consideration the very feature that many philosophers identify as uniquely constitutive of humanity. That is, what distinguishes us from other animals and makes us distinctly human is not the ability to satisfy our goals, but the ability to reason and deliberate about the content of those goals. Indeed, the very project of life might be said to consist of shaping, revising, and reflecting on one's goals or, put differently, on what one wants to want. A final concern with CBA, then, is that the methodology seems ill-suited to grapple with this central project of life.
>
> In very simplistic terms, CBA asks whether diverting resources from current patterns of production and consumption toward climate change mitigation would produce a net enhancement of social welfare. The benefits of mitigation – avoided human deaths, preservation of ecosystems, survival of other species, and so on – are compared to the opportunity cost of whatever utility would have been provided by the foregone combustion of fossil fuels. The reference case for defining and measuring utility in this process remains unequivocally focused on the status quo pattern of production and consumption. No allowance therefore is made for the possibility of individuals to adapt their preferences in light of changed circumstances, to acknowledge the moral responsibility created by climate change, to accept as being well and just any newly imposed constraints on their harmful activities, or simply to get on with the project of life by deriving utility in new but not necessarily inferior ways. In short, no allowance is made for the possibility of individuals to grow.[185]

In sum, Professor Kysar contends that "CBA, by its very design, is ill-equipped to grapple with deep scientific uncertainty, to reliably value human life and respect the existence of other beings, to assess and honor the needs and rights of future generations, or to contemplate, discuss, and pursue as-yet-unrealized ways and modes of living. Without these capabilities, CBA offers only meager assistance to climate change policymaking."[186] He laments the failure of these and related criticisms to "slow the

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[184] Kysar, *Climate Change*, *supra* note 182, at 558 (citing DAVID DRIESEN, THE ECONOMIC DYNAMICS OF ENVIRONMENTAL LAW 4 (2003)).
[185] *Id*. at 586-87.
[186] *Id*. at 589-90.

drive" toward the universal application of CBA to environmental policy and charges that "international action on climate change [is] currently being thwarted by the United States at least in part due to arguments premised on CBA."[187] Professor Kysar favors reliance on a form of the precautionary principle[188] as an example of dynamic, incremental, and pragmatic decisionmaking model.[189] He contests in particular the charge that the precautionary principle's "ignorance of the opportunity costs of precaution leads to indeterminate or impoverishing policy advice."[190]

Even if policymakers decide that it makes sense to engage in a CBA of alternative approaches to global climate change, however, it is inappropriate to limit the comparison to "uncertain future benefits against certain costs today." While a delay will defer the compliance costs that current regulations requiring GHG emission reductions would otherwise entail, many scientists are convinced that delay will significantly increase the costs of addressing global climate change in the future.[191] Environmental policymakers therefore ought to be comparing the cost-benefit ratios of regulating now and in the future to make the most informed policy choices possible. In other words, there are opportunity costs involved both in acting now and in waiting to act until more information is available.

It is not clear that the federal government has based its failure to aggressively address human activities that are likely to be contributing to global climate change on that kind of comparative analysis. Studies conducted by others, however, have concluded that, on a global scale, the cost-benefit ratio of regulating GHG emissions is favorable, especially if action is taken sooner rather than later. One recent study concludes that if nothing is done to restrain GHG emissions, annual global economic damages could reach $20 trillion (in 2002 dollars), between six and eight percent of global economic output at that time. That study finds that immediate adoption of climate protection policies could eliminate more than half of the damage. Further, the later control efforts begin, the more expensive they will be.[192] Another recent modeling effort estimates that, in the absence of new climate change policies, the discounted present value of all cumulative climate damages from 2000 to 2200 will total $74 trillion (at 2000 prices), with annual average damages of about $26 trillion. Again, the study finds that more than half of these damages can be avoided through the immediate adoption of active climate change policies.[193] Moreover, the damage totals provided by these modeling efforts do not

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[187] *Id*. at 559.

[188] The precautionary principle "seeks to trigger an incremental process of risk regulation through the simple admonition, 'When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause-and-effect relationships are not fully established.'" Kysar, *Opportunity Costs*, *supra* note 81, at 3-4 (quoting Peter Montague, *The Precautionary Principle*, RACHEL'S ENV'T & HEALTH WKLY., Feb. 19, 1998, at 1, *available at* http://www.monitor.net/rachel/r586.html).

[189] *Id*. at 8. For a comprehensive discussion of the application of the principles of pragmatism to environmental policymaking that eschews the kind of comprehensive rationality of which CBA is the paradigm, see SHAPIRO & GLICKSMAN, *supra* note 183.

[190] Kysar, *Opportunity Costs*, *supra* note 181, at 6.

[191] *See supra* note 14 and accompanying text.

[192] Ackerman & Stanton, *supra* note 105, at 24-25.

[193] *Id*. at 25 (citing Paul Watkiss et al., *The Impacts and Costs of Climate Change* (2005)).

include "all of the non-market and socially contingent impacts of climate change" or "the uncertain but growing risks of true catastrophe. The models' enormous damage estimates, reaching unimaginable levels of trillions of dollars (or pounds), still necessarily omit some of the most troubling potential consequences of climate change."[194]

One of the most comprehensive studies of the potential costs and benefits of controlling GHG emissions (or of failing to do so), is the *Stern Review on the Economics of Climate Change*, submitted in October 2006 by the Head of the Government Economics Service and Adviser to the Government (who is also a former chief economist of the World Bank) to the British Prime Minister and the Chancellor of the Exchequer on the Economics of Climate Change.[195] The *Review* concludes that "[w]ith good policies the costs of action need not be prohibitive and would be much smaller than the damage averted."[196] Based on economic models, the *Review* concludes in particular that if no action is taken to abate human contributions to global climate change, the costs of climate change "will be equivalent to losing at least 5% of global GDP each year, now and forever. If a wider range of risks and impacts is taken into account, the estimates of damage could rise to 20% of GDP or more."[197] The *Review* warns that these estimates are laden with uncertainty, thus reinforcing the arguments addressed above that there are good reasons to be skeptical of the value of CBA as a technique for environmental policymaking. The uncertainty stems in part from the need, "if the model is to quantify the full range of effects, [to] place monetary values on health and the environment, which is conceptually, ethically and empirically very difficult. But given these caveats, even at the optimistic end of the 5-20% range, 'business as usual' climate change implies the equivalent of a permanent reduction in consumption that is strikingly large."[198]

According to the *Review*, the costs of taking effective action to redress the worse aspects of climate change by reducing GHG emissions can be limited to about one percent of global GDP each year, assuming strong action commences now.[199] More specifically, the *Review* calculates the annual cost of cutting total GHG emissions by

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[194] *Id*.
[195] STERN REVIEW, *supra* note 10.
[196] *Id*. at iv.
[197] *Id*. at vi. More specifically, the *Review* makes the following findings:

> Our estimate of the total cost of "business as usual" (BAU) climate change over the next two centuries equates to an average welfare loss equivalent to at least 5% of the value of global per-capita consumption, now and forever. That is a minimum in the context of this model, and there are a number of omitted features that would add substantially to this estimate. Thus the cost is shown to be higher if recent scientific findings about the responsiveness of the climate system to [GHG] emissions turn out to be correct and if direct impacts on the environment and human health are taken into account. Were the model also to reflect the importance of the disproportionate burden of climate-change impacts on poor regions of the world, the cost would be higher still. Putting all these together, the costs could be equivalent to up to around 20%, now and forever.

Id. at 144.
[198] *Id*. *See also id*. at 163 (explaining why the cost of BAU would "probably" amount to a 20% cut in per capita consumption, "now and forever"); *id*. at 164 (stating that the economic risks of BAU are "probably more severe than suggested by past models").
[199] *Id*. at vi-vii.

about three-quarters of current levels by 2050 as anywhere from -1.0 to +3.5 percent of GDP, with an average estimate of about one percent.[200] The *Review* admits that different modeling approaches would generate a somewhat different range of costs, but asserts that these differences "do not obscure the central conclusion that climate-change mitigation is technically and economically feasible at a cost of around 1% of GDP," and that, although the costs would not be small, "they are also not high enough seriously to compromise the world's future standard of living."[201] The *Review* concludes in particular that a technology-based approach to reducing GHG emissions will cost about $1 trillion by 2050, "which is relatively modest in relation to the level and expansion of economic output over the next 50 years, which in any scenario of economic success is likely to be over one hundred times this amount."[202] The *Review* defines the minimal essential components of an effective strategy to reduce GHG emissions as the pricing of carbon (through taxation, trading, or regulation), support for innovation and the deployment of low-carbon technologies, and action to remove barriers to energy efficiency and to educate individuals about what they can do to contribute to mitigation of the adverse effects of global climate change.[203] According to the *Review*, "[t]he better the policy, the lower the cost."[204]

The longer the world waits to implement such a strategy, the harder and more expensive it will be to avert drastic adverse consequences. According to the *Review*, "[d]elay would be costly and dangerous";[205] if GHG emission continue at their current rate, "the outlook is even worse."[206] Concisely stated, the *Review* asserts that "the

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[200] *Id*. at 211. The Energy Information Administration has calculated that implementation one version of an economy-wide cap on GHG emissions, accompanied by a cap-and-trade emissions trading system, would increase energy prices in the United States by 6% by 2020, with ripple effects on other aspects of the economy. *See* Energy Information Administration, *Energy and Economic Impacts of H.R.5049, the Keep America Competitive Global Warming Policy*, *available at* http://www.eia.doe.gov/oiaf/servicerpt/economicimpacts/index.html. An industry-funded study done at the Wharton School projected the costs of U.S. adherence to the Kyoto Protocol to include a loss of 2.4 million jobs and $300 in national GDP. According to Professor Cass Sunstein, however, "[t]hese figures are almost certainly inflated," in part because of the possibility that emissions trading and technological innovation would reduce the costs of compliance. Cass R. Sunstein, *Montreal Versus Kyoto: A Tale of Two Protocols*, AEI-Brookings Joint Center for Regulatory Studies, Working Paper No. 06-17, at 24 (forthcoming in __ HARV. ENVTL. L. REV. ___), *available at* http://ssrn.com/abstract=91335. Professor Sunstein argues that "[i]t is difficult to doubt the proposition that the Kyoto Protocol would be worthwhile if it would eliminate the total cost of climate change," but that the Protocol would only reduce anticipated warming by a "meager" amount. *Id*. at 26. He claims that the $12 billion in benefits that the United States would accrue under the Protocol would be "dwarfed" by the anticipated costs of $325 billion. *Id*. at 27. These numbers are not necessarily inconsistent with the analysis in the *Review*, which finds that the more effective the policies adopted are at mitigating the adverse effects of global climate change, the more cost beneficial they will be.

[201] STERN REVIEW, *supra* note 10, at 212.

[202] *Id*. at 236.

[203] *Id*. at viii.

[204] *Id*. at 211. *See also id*. at 236 (concluding that "the more imperfect, less rational, and less global policy is, the more expensive it will be").

[205] *Id*., Executive Summary at xxvii.

[206] *Id*. at 170. *See also id*. at 211 (stating that "[w]ithout early well-planned action, the costs of mitigating emissions will be greater").

evidence gathered by the Review leads to a simple conclusion: the benefits of strong, early action considerably outweigh the costs."[207]

Moreover, the *Review* dismisses the choice between economic growth and environmental control as a false one, stating that "[t]he world does not need to choose between averting climate change and promoting growth and development. Changes in energy technologies and in the structure of economies have created opportunities to decouple growth from [GHG] emissions. Indeed, ignoring climate change will eventually damage economic growth."[208]

A CBA of efforts to abate global climate change in the United States obviously will not necessarily track the figures provided in these studies of the potential worldwide costs and benefits of global climate change. The global studies, however, arguably are relevant to the formulation of domestic energy and environmental policy related to global climate change. As it stands, both the precautionary principle and at least some efforts to conduct a global CBA of alternative climate change policies support government intervention sooner rather than later.

D. The Impact of Hurricane Katrina on U.S. Policy on Global Climate Change

In light of the federal government's failure to address the threats posed by global climate change to date, is the occurrence of Hurricane Katrina likely to affect the future posture of federal environmental policy related to climate change? One of the factors that affect government policy on environmental regulation is public opinion. Professor David Dana claims, for example, that "at least in representative democracies, environmental policy will reflect popular opinion to some extent. Politicians and government officials will be significantly affected by the opinion of voters."[209] But scholarship on the relationship between cognitive psychology and environmental policy has identified several reasons why a shift in the government's response to the threats posed by global climate change fueled by bottom-up pressure based on popular opinion may not be imminent. These include the lack of scientific consensus on the scope of the threat and the intangible and seemingly remote nature of that threat.[210]

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[207] *Id*., Executive Summary at ii.
[208] *Id*. at viii.
[209] David A. Dana, *A Behavioral Economic Defense of the Precautionary Principle*, 97 NW. U. L. REV. 1315, 1330 (2003). *See also id*. at 1330 n.43 (asserting that environmental regulation applicable to pollution from small sources such as individuals, households, and small businesses "invariably is highly sensitive to broad public opinion"). *See also* Paul Boudreaux, *Federalism and the Contrivances of Public Law*, 77 ST. JOHN'S L. REV. 523, 595 (2003) (claiming that "if public opinion were galvanized by a revival of toxic 'scares' like those of Times Beach, Missouri, and Love Canal, New York, in the 1970s and 1980s, the balance of national political opinion might shift"). *But cf*. Cary Coglianese, *Social Movements, Law, and Society: The Institutionalization of the Environmental Movement*, 150 U. PA. L. REV. 85, 88 (2001) (arguing that, "[e]ven though public opinion has served to prevent a large-scale retreat from existing environmental controls, prevailing public sentiment tends to be latent and insufficient to support another transformational expansion of environmental regulation").
[210] Jeffrey J. Rachlinski, *The Psychology of Global Climate Change*, 2000 U. ILL. L. REV. 299, 303, 306-07. A risk's diffusion in time and space tends to lessen public concern over it. *See* ZYGMUNT J.B. PLATER ET

As Part III B above indicates, the debate between proponents of the climate change and AMO hypotheses of the relationship between global climate change and hurricane intensity (which has been spurred to some extent by Hurricanes Katrina and Rita), seems to be coalescing around the view that climate change is linked to hurricane intensity. If scientists reach such a consensus, and if that consensus is publicized in the popular press, the lack of consensus that the public has perceived over the causes of climate change may cease to be a significant obstacle to a build-up of public pressure on the federal government to tackle climate change.

Hurricane Katrina may be even more important if it eliminates the obstacle to public support for a more active governmental response to the phenomenon of climate change that is based on the remoteness and intangible quality of the risks posed by that phenomenon. Because of the availability heuristic, "[w]hen estimating the likelihood or frequency of an event, people rely on the ease with which an example of that event can be imagined or called to mind."[211] As Professor Jeffrey Rachlinski has argued:

> The threat of global climate change provides more than adequate opportunity to create an availability cascade. The climate itself is difficult for laypersons to track, but the alleged symptoms of global climate change are easy to imagine. With or without a dramatic change in climate, bad weather constantly finds its way into the news. Droughts, tornadoes, hurricanes, floods, and heat waves consistently receive coverage on the nightly news, whether or not they are the products of global climate change. This attention makes it easier to recall instances of weather-related tragedies, making the prospect of a disastrous change in the climate seem likely.[212]

The graphic televised images of Katrina are likely to spring easily to mind if scientists or policymakers argue that an aggressive effort to address climate change is necessary to reduce the risks of more severe storms in the future.

It would not be surprising if Katrina were to spark more vigorous public support for a shift in domestic climate change policy. One of the recurring patterns in environmental law is the tendency of Congress to adopt environmental legislation in response to widely publicized environmental disasters.[213] The Santa Barbara oil spill of

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AL., ENVIRONMENTAL LAW AND POLICY: NATURE, LAW, AND SOCIETY 247 (3d ed. 2004) (quoting Peter Sandman, *Risk Communication: Facing Public Outrage*, 13 EPA J. # 9, Nov. 1987, at 21-22).

[211] Rachlinski, *supra* note 210, at 311.

[212] *Id.* at 312.

[213] As Professor Jonathan Cannon has argued, "[u]rgency, the sense that environmental problems pose threats requiring a strong collective response, has been environmentalism's motive force. This sense animated Congress' enactment of the federal environmental laws of the 1970s and '80s, which restructured institutional arrangements to address a range of perceived environmental crises." Jonathan Cannon, *Environmentalism and the Supreme Court: A Cultural Crisis*, 33 ECOL. L.Q. 363, 409 (2006). *See also* Pamela Howlet, *Striking the Right Balance: Contrasting the Ways in Which the United States and China Implement National Projects Affecting the Environment*, 12 MO. ENVTL. L. & POL'Y REV. 17, 20 (2004) (stating that "[t]he widespread occurrences of environmental crises created pressure on the federal government to take action"); Christopher N. Behre, *Mexican Environmental Law: Enforcement and Public*

1969, the burning of the Cuyahoga River in the early 1970s,[214] the discovery of chemical waste contamination at the Love Canal near Niagara Falls,[215] the release of deadly chemicals into the air from Union Carbide's plant in Bhopal, India,[216] and the Exxon Valdez oil spill in 1989,[217] to cite but a handful of examples, all played a significant role in increasing public awareness of environmental issues that facilitated the adoption of major federal environmental legislation.[218] Professor Cass Sunstein claims that, although the federal government's "unaggressive posture" toward global climate change reflects the attitudes of the American public, public opinion is malleable and that "[a] salient public event – a kind of 9/11 for climate change – might be sufficient to change those attitudes."[219]

Participation Since the Signing of NAFTA's Environmental Cooperation Agreement, 12 J. TRANSNAT'L L. & POL'Y 327, 332 (2003) (stating that "United States environmental statutes . . . were generally developed individually and in response to specific crises").

[214] "The Santa Barbara oil spill gave the public its first view of a devastating oil spill. As a result of this media blitz and growing environmental consciousness, President Nixon was forced to pass sweeping pieces of environmental legislation such as the National Environmental Protection Act and the Clean Air Act." Bruce Clotworthy, *Energy, the Environment, and Public Opinion*, 42 NATURAL RES. J. 981, 982 (2002) (book review). *See also* Robert H. Cutting & Laurence B. Cahoon, *Thinking Outside the Box: Property Rights as a Key to Environmental Protection*, 22 PACE ENVTL. L. REV. 55, 80 (2005) (asserting that "the public awareness stirred by the Santa Barbara oil spill, the Cuyahoga River fires and Silent Spring galvanized Congress in the 1960's to create the grand statutory schemes that we know as modern environmental law"). One reflection of the impact of the Cuyahoga River fires on public opinion and popular culture is Randy Newman's song, "Burn On," on his album, *Sail Away* (Reprise Records 1972). Newman wrote: "There's an oil barge winding/Down the Cuyahoga River/Rolling into Cleveland to the lake/ . . . Cleveland, even now I can remember/'Cause the Cuyahoga River/Goes smokin' through my dreams/Burn in, big river, burn on . . . ."

[215] "Congress gave EPA . . . new mandates in reaction to perceived environmental catastrophes that were well publicized and dominated the front page news. For example, . . . Love Canal, near Niagara Falls, became the poster-child for contaminated industrial properties and gave birth to the Superfund statute." Robert M. Sussman, *Science and EPA Decisionmaking*, 12 J. L. & POL'Y 573, 575 (2004). *See* the Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9601-9675.

[216] *Id*. at 575-76 (stating that "the catastrophic release of methyl isocyanate at the Union Carbide facility at Bhopal, India, which killed hundreds of people, led to the creation of a community right-to-know and emergency response system in this country"). *See* the Emergency Planning and Community Right-to-Know Act, 42 U.S.C. §§ 11001-11050.

[217] Michael B. Gerrard, *Emergency Exemptions from Environmental Laws After Disasters*, 20-SPG. NAT. RESOURCES & ENV'T 10, 10 (2006) (stating that "the Exxon Valdez spill in Alaska in 1989 led to the Oil Pollution Act of 1990"). *See* the Oil Pollution Act of 1990, 33 U.S.C. §§ 2701-2761.

[218] *See generally* Gerrard, *supra* note 217, at 10 (arguing that "[m]any environmental statutes had their origins in disasters. And when disasters strike, the environmental laws come into play in the response."). *See also* Michael Bargava, Comment, *Of Otters and Orcas: Marine Mammals and Legal Regimes in the North Pacific*, 32 ECOL. L.Q. 939, 971 (2005) (contending that televised reports of northern fur seals on the Pribilof Islands in the late 1960s and early 1970s "outraged many Americans," and that "the slaughter of thousands of dolphins in a new fishery for tuna that had developed in the Pacific in the late 1960s using purse seines galvanized thousands of Americans" into pressuring the government to adopt new environmental protection laws).

[219] Sunstein, *supra* note 200, at 35. Katrina, however, also provided an excuse for politicians to clamor for exempting activities such as oil and gas exploration and development from environmental regulatory obligations to mitigate the effects of the emergency on the economy. *See generally* Gerrard, *supra* note 217.

Speculations aside, has Hurricane Katrina actually provided the spark that prompts the adoption of legislation directed at the threats of global climate change? The environmental threats associated with climate change seem to strike a somewhat stronger chord with the American public today than they did several years ago, although the change does not seem as dramatic as the public response to some of the environmental disasters mentioned above. In a Newsweek poll conducted in April 2000, only 12 percent of those responding to the question of whether global warming constituted one of "the most important environmental problems facing the world today" said that it did.[220] Several months later, 46 percent of those responding to a Harris poll stated that they believed that "the possibility of global warming should be treated as a very serious problem," while an additional 39 percent regarded it as a "somewhat serious" problem, and thirteen percent said it was "not serious."[221] In April 2001, an ABC News poll posited that "some people say" that a commitment by the U.S. to the Kyoto Protocol "would hurt the U.S. economy, and is based on uncertain science. Others say this is needed to protect the environment, and could create new business opportunities." The poll then inquired whether respondents thought the U.S. "should or should not join this treaty requiring less emissions from U.S. power plants and cars." Sixty-one percent of the respondents said the U.S. should join, while 26 percent said it should not.[222]

Similarly, a September 2002 Harris poll asked: "Do you approve or disapprove of the international agreements in Kyoto and Bonn which would require countries to limit their emissions of carbon monoxide and other greenhouse gases?" Seventy-three percent said yes, while 20 percent said no.[223] The same poll inquired whether the respondents had "ever seen, heard or read about the theory of global warming – that average temperatures are rising slowly and will continue to rise mainly because of the burning of coal, oil and other fuels?" Eighty-five percent said yes and 14 percent said no.[224] Yet, only 52 percent of those who said they had heard of the theory of global warming said they had "seen, heard or read of recent international agreements in Kyoto and Bonn to limit emissions of carbon dioxide and other greenhouse gases to reduce global warming." Forty-five percent said they had not.[225] Finally, of those who said they had heard of global warming, 54 percent said they thought the position of the U.S. government in saying that it cannot accept the Kyoto and Bonn agreements to limit emissions of GHGs "because they are not based on sound research and would damage the American economy" was wrong. Thirty percent said it was right.[226] In March 2004, a Gallup poll

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[220] PollingReport.com, *Environment*, *available at* http://pollingreport.com/enviro.htm. Four other environmental problems (air pollution, water pollution, garbage and landfills, and loss of the ozone layer) ranked higher.

[221] *Id*. The percentages responding to the same question in a 1997 Harris poll were 47, 40, and 11, respectively. *Id*.

[222] *Id*.

[223] *Id*. A year earlier, the numbers were 70 and 22%, respectively. The responses to another question in the same poll were almost identical. Seventy-four percent of the respondents said they "believe the theory that increased carbon dioxide and other gases released into the atmosphere will, if unchecked, lead to global warming and an increase in average temperatures." Nineteen percent said they did not.

[224] *Id*. Two years earlier, 89% had heard of global warming and only 10% had not. Had 4% forgotten what they knew in the interim?

[225] *Id*.

[226] *Id*.

inquired whether the U.S. should or should not agree to abide by the provisions of the Kyoto Protocol on global warming. Forty-two percent of the respondents said the U.S. should abide by the treaty, 22 percent said it should not, and 36 percent said they had no opinion.[227] Thus, the public's commitment to that particular policy response to global climate change had actually fallen since September 2002.

Then came Hurricane Katrina at the end of August 2005, followed shortly thereafter by Hurricane Rita. In an ABC News/Washington Post poll conducted a few weeks after Katrina, the pollsters asked: "How convinced are you that global warming or the greenhouse effect is actually happening? Would you say you are completely convinced, mostly convinced, not so convinced or not convinced at all?" The responses were 23, 33, 22, 17 respectively (four percent said they were not sure). A few months before Katrina, the answers to the same question were very similar: 23, 36, 24, and 16 (with two percent unsure).[228] In the same poll, respondents were asked the following question: "Do you think global warming is an urgent problem that requires immediate government action, or a longer-term problem that requires more study before government action is taken?" Forty-one percent said it is an urgent problem, 47 percent said it is a long-term problem, six percent said it is not a problem, and six percent said they were unsure. A few months before Katrina, 38 percent said it is an urgent problem, 58 percent said it was a longer-term problem, three percent said it is not a problem, and one percent said they were unsure.[229] Thus, seven percent fewer people viewed global warming as a long-term problem after Katrina than before, and three percent more people viewed it as an urgent problem after Katrina than before.

Finally, in a question obviously relevant to whether Katrina contributed to a shift in public attitudes toward global warming, the same poll asked: "Do you think the severity of recent hurricanes is most likely the result of global climate change, or is it just the kind of severe weather events that happen from time to time?" Thirty-nine percent said global warming is the likely cause of severe hurricanes, while 54 percent said they "just happen."[230] Several weeks later, a CNN/USA Today/Gallup poll posed similar question about the potential link between global climate change and hurricane activity. The poll inquired: "Thinking about the increase in the number and strength of hurricanes in recent years, do you think global warming has been a major cause, a minor cause, or not a cause of the increase in hurricanes?" This time, 36 percent said global warming is a major cause, an additional 29 percent said it is a minor cause, 30 percent said it is not a

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[227] *Id*. The same poll posited that "[r]ecently, a group of prominent scientists charged that the Bush Administration is ignoring and distorting scientific evidence concerning the seriousness of environmental problems such as global warming." It then inquired: "How much have you heard about this criticism before now: a great deal, a moderate amount, not much, or nothing at all?" The responses were 8, 26, 40, and 26 %, respectively. Finally, the same poll asked: "Who do you tend to believe in this matter: the scientists who claim that the Bush Administration is ignoring and distorting scientific evidence about environmental problems, OR, the Bush Administration, which denies ignoring and distorting scientific evidence about environmental problems?" Fifty-nine percent of the respondents said they believed the scientists and only 32% said they believed the Bush Administration. Nine percent had no opinion. *Id*.

[228] *Id*.

[229] *Id*

[230] *Id*. Seven percent of the respondents said they were unsure.

cause, and five percent said they were unsure.[231] It is possible to interpret these responses as reflecting an increase in the percentage of those who believe in a link of some magnitude between global climate change and hurricane activity. Whereas 54 percent said that hurricanes likely "just happen" in response to the ABC News/ Washington Post poll, a total of 65 percent responded to the CNN poll a month later that there is a link of some degree between the two phenomena. Perhaps publicity over the hurricane generally, and over the possible effects of global climate change on storm activity in particular, had some effect on public opinion.

More recent polls also support the view that Katrina may have made an impression on people's views about global climate change, but not a demonstrably dramatic one. ABC News, Time, and Stanford University conducted a poll in March 2006 that included a series of questions related to global climate change. One question began this way: "You may have heard about the idea that the world's temperature may have been going up slowly over the past 100 years. What is your personal opinion on this? Do you think this has probably been happening, or do you think it probably hasn't been happening?" Eighty-five percent of the respondents answered that it has been happening; only 13 percent said it has not. The follow-up question was this: "Do you think a rise in the world's temperatures is being caused mostly by things people do, mostly by natural causes, or about equally by things people do and by natural causes?" Thirty-one percent said people, and an additional 49 percent said people and natural causes are equal causal factors. Only 19 percent said nature is the sole factor in increasing temperatures. The next question inquired whether, "[i]f nothing is done to reduce global warming in the future," the result will be a "very serious" problem for the U,S, a "somewhat serious" problem, a "not so serious" problem, or "not serious at all?" Forty-nine percent said very serious and an additional 34 percent said somewhat serious. Only ten and six percent said not so serious or not serious at all, respectively.[232] These numbers are similar to those provided in response to the 2000 Harris poll.[233]

The March 2006 poll also asked whether the respondents thought that "the federal government should do more than it's doing now to try to deal with global warming, should do less than it's doing now, or is it doing about the right amount?" The responses were 68, 5, and 25 percent, respectively. Obviously, public support for a more aggressive government response to global climate change was strong, but the 65 percent in favor of doing more is only slightly higher than the 61 percent who favored joining the Kyoto Protocol in April 2001 ABC News poll. The March 2006 poll inquired what the respondents would "rather see the federal government do: require companies and individuals to do things to reduce global warming; offer tax cuts to encourage these things, but not require them; or do nothing to influence whether companies and individuals do these things?" Fifty-two percent said require, 38 percent said encourage,

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[231] *Id*.

[232] *Id*. The poll asked the same question with respect to the world, rather than the United States. The responses to whether a failure to act would pose a problem for the world were as follows: 57% – very serious; 28% – somewhat serious; 8% – not so serious; and 5% – not serious at all.

[233] *See supra* note 221 and accompanying text.

and only eight percent said do nothing.[234] Sixty-one percent supported action by the government to lower the amount of GHGs power plants are allowed to release, while 26 percent said the government should encourage such reductions. Eleven percent said the government should do nothing to reduce GHG emissions from power plants.[235]

Gallup conducted a poll in the same month. It inquired whether the respondents personally worry about "the greenhouse effect" or "global warming." Thirty-six percent said a great deal, and an additional 26 percent said a fair amount. Twenty-one percent said only a little, and 15 percent said not at all. Ten percent more people said a great deal than had done so when asked the same question two years before, which was a year and a half before Katrina. Seven percent fewer people said only a little in 2006, as compared to 2004, and four percent fewer said not at all.[236] The pollsters asked the respondents the following question in "thinking about the issue of global warming, sometimes called the 'greenhouse effect'": "How well do you feel you understand this issue?" Twenty-one percent said "very well," 53 percent said "fairly well," twenty percent said "not very well," and six percent said "not at all?" The poll asked another question about the timing of the effects of global warming. Fifty-eight percent said these effects are already happening, a four percent increase since March 2005, several months before Katrina. Five percent they will happen within a few years (the same number giving this response in March 2005). Ten percent said they will happen within their lifetimes (the same as in March 2005), fifteen percent said that only future generations will be affected (as compared to 19 percent in March 2005), and eight percent said never (as compared to nine percent in 2005).[237]

The poll also asked, based on what the respondents had heard or read: "Do you believe increases in the Earth's temperature over the last century are due more to the effects of pollution from human activities, or natural changes in the environment that are not due to human activities?" Fifty-eight percent said human activities, 36 percent said natural changes, and six percent were unsure. Finally, the poll posed the following question: "Thinking about the increase in strength of hurricanes in recent years, do you think global warming has been a major cause, a minor cause, or not a cause of the increase in strength of hurricanes?" Thirty-five percent responded that global warming is a major cause, 33 percent said it is a minor cause, 26 percent said it is not a cause, and six percent were unsure.[238] These numbers reflect a three percent increase since the ABC/Washington Post poll asked the same question a few weeks after Katrina in those

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[234] PollingReport.com, *supra* note 220. The poll also posed a series of options for the federal government and asked whether the respondents would favor or oppose each one. More people favored affording tax breaks to producers of GHGs than those who favored increasing taxes on electricity or gasoline.

[235] *Id*.

[236] *Id*.

[237] *Id*. Thirty percent of the respondents said they believed the seriousness of global warming is exaggerated in what is generally said in the news, 28% said the news is generally correct, 38% said the seriousness is underestimated, and 4% said they were unsure. *Id*. Another question asked the respondents to assess the accuracy of the following statements: "Most scientists believe that global warming is occurring. Most scientists believe that global warming is NOT occurring. OR, Most scientists are unsure about whether global warming is occurring or not." Sixty-five percent said "is occurring," 3% said not occurring, and 29% said unsure.

[238] *Id*.

who said global warming is either a major or minor cause of the increase in hurricane activity, and a four percent decrease in those who said it is not a cause.[239]

A CBS/New York Times poll conducted in May 2006 asked whether the respondents think "global warming is an environmental problem that is causing a serious impact now, or do you think global warming isn't having a serious impact?" Sixty-six percent said the impact is serious now, as compared to 59 percent who gave that response in a poll conducted two years before Katrina. Thirty percent said it is not having a serious impact, a decrease of seven percent since the earlier poll.[240] Again, these figures may support the conclusion that Katrina and the publicity that surrounded it marginally raised public consciousness and concern over global climate change.

The thesis that Katrina has had an impact on public perceptions of global climate change is perhaps best supported by the latest available poll numbers, which come from a Los Angeles Times/Bloomberg poll conducted in July and August 2006 (eleven months after Katrina). The first relevant question was whether "the Bush Administration [is] doing too much, or too little, or just the right amount to reduce global warming?" Only three percent said too much, while 58 percent said too little. Twenty-nine percent said the right amount and ten percent were unsure.[241] These responses reflect less ambiguity about the need for more federal initiatives to address global climate change than in some of the earlier polls.[242] The second relevant question took the following form: "As you may know, scientists have found evidence that the earth's climate is warming. From what you have heard or read, do you think global warming is a very serious problem, a somewhat serious problem, not too much of a problem or not a problem at all, or haven't you heard enough about this to say?" The answers were 73, 19, 6, and two percent, respectively.[243] The percentage of those who do not perceive global warming as a currently serious problem is eleven percent lower than those who gave a similar response in the May 2006 CBS/ New York Times poll.[244] Compared to the 2000 Harris poll, 27 percent more respondents characterized global warming as a "very serious problem."[245] The third relevant question was as follows: "What do you think is causing global warming? Do you think it is caused more by human activities, such as driving cars and burning fuel, or is it caused more by natural changes in the climate?" Forty-seven

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[239] *See supra* note 231 and accompanying text.
[240] PollingReport.com, *supra* note 220. An NBC News/ Wall Street Journal poll asked a similar question in June 2006. The question was this: "From what you know about global climate change or global warming, which one of the following statements comes closest to your opinion? [1] Global climate change has been established as a serious problem, and immediate action is necessary. [2] There is enough evidence that climate change is taking place and some action should be taken. [3] We don't know enough about global climate change, and more research is necessary before we take any actions. [4] Concern about global climate change is unwarranted." The responses were: [1] 29%, [2] 30%, [3] 28%, and [4] 9%. In July 1999, the responses to the same question were 23%, 28%, 32%, and 11%. *Id*. Thus, there was a 6% rise in those who supported immediate action, a 4% decline in those who wanted more research before acting, and a 2% decline in those who said no action is warranted.
[241] *Id*.
[242] *See supra* notes 221-22, 226 and accompanying text.
[243] PollingReport.com, *supra* note 220.
[244] *See supra* note 240 and accompanying text.
[245] *See supra* note 221 and accompanying text.

percent said human activities, 32 percent said natural changes, and 16 percent said both.[246] Compared to the March 2006 ABC News poll, sixteen percent more people identified human activity as the cause of global warming and three percent fewer said nature is the sole factor in increasing temperatures.

These polling results indicate a trend in public attitudes over the last six years toward the positions that global warming is a serious environmental problem now, that human activities are the primary cause of that problem, and that the federal government ought to be doing more than it is currently doing to address the threats posed by changes in global climate. According to some observers, "the catastrophe of Katrina . . . arguably focused public concern about global warming more than any other issue or event hitherto."[247] Perhaps Katrina has not had the "salience" of an Exxon Valdez or a Love Canal – in Professor Sunstein's phrase, it does not seem to have been "a kind of 9/11 for climate change."[248] It does seem, however, to have either provided an incremental spur to the public's growing concern about the risks of global climate change and its belief in the need for a more active governmental response, or at least to have reinforced a trend in that direction that had already begun before the hurricane hit in 2005. It is therefore perhaps not coincidental that some of the most important state initiatives to combat global warming have occurred since Katrina. These include the adoption of a Memorandum of Agreement among the northeastern states committed to the Regional Greenhouse Gas Initiative, the adoption by some states of regulations requiring reductions in GHG emissions from motor vehicles, and the initiation of common law public nuisance actions by local governments against various sources of GHG emissions, including electric utilities and the auto manufacturing industry.[249]

Due in large part to the persistent opposition of the executive branch and congressional majorities in the last few years, the federal government has not leaped onto this bandwagon. Instead, it has tried to grind the momentum toward effective regulatory action directed at mitigating the effects of global climate change to a halt.[250] These foot-dragging efforts may be harder to sustain than they used to be. Support for meaningful action to combat global climate change appears to be growing in the U.S. Senate. Even some segments of industry have begun to a shift in the federal government's response to climate change. If Katrina and the publicity surrounding the scientific debate described in Part III B of this particle have not been the principal causes in the apparent growth of sentiment in favor of such action, they may at least have been contributing factors.

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[246] PollingReport.com, *supra* note 220 and accompanying text.
[247] Curry et al., *supra* note 53, at 1033.
[248] *See supra* note 219 and accompanying text.
[249] Many of these initiatives are described in Glicksman, *supra* note 109, at 781-86. In addition, in 2006, California adopted the Global Warming Solutions Act of 2006, Cal. Health & Safety Code §§38501-38599. The Act requires the State Air Resources Board to adopt a statewide GHG emissions limit, to be achieved by 2020, that is equivalent to the statewide level in 1990. The Board also must adopt regulations to achieve the maximum technologically feasible and cost-effective emission reductions of GHGs (which include CO_2, methane, nitrous oxide, and HCFCs) from categories of sources.
[250] *See, e.g.*, Glicksman, *supra* note 109, at 794 (describing the federal government's efforts to preempt state regulation of GHG emissions).

V. CONCLUSION

The answer to the question "what caused Katrina" may very well be of little practical value, at least to the extent that global climate change may have been a contributing factor. It is nevertheless critically important to analyze whether global climate change due to human activity such as GHG emissions is likely to contribute to more severe storm cycles or to increased risks of coastal flooding in the future. Although the question is certainly not free from doubt, there is evidence (regarded by some as merely suggestive, but by others as compelling) that increases in sea surface temperatures caused by anthropogenic global climate change rather than only by natural climatic cycles are correlated to increased hurricane severity. The evidence is even more substantial that global temperature increases due to anthropogenic activities create risks of serious coastal flooding in the future due to the melting of polar ice caps and glaciers.

Both of these potential consequences of global climate change are causes for concern in low elevation coastal areas such as New Orleans and its environs. Scientists on both sides of the debate concerning the connection (or lack thereof) between global climate change and hurricane activity issued a joint statement at the beginning of the 2006 North Atlantic hurricane season urging policymakers not to allow the debate, albeit of "considerable scientific and societal interest and concern," to "detract from the main hurricane problem facing the United States: the ever-growing concentration of population and wealth in vulnerable coastal regions. These demographic trends are setting us up for rapidly increasing human and economic losses from hurricane disasters, especially in this era of heightened activity."[251] It may be that the most immediate threats or the threats of greatest magnitude that are associated with global climate change are the threats of catastrophic future hurricane damage. But there are myriad independent reasons to engage in vigorous efforts to mitigate the adverse effects of human contributions to global climate change.[252] Further, the existence of the threats of increased hurricane intensity and coastal flooding are sufficient to suggest that policymakers should seek to minimize human contributions to global climate change for multiple reasons and through multiple avenues.[253] As Part IV of this article demonstrates, the federal government has been notably delinquent in fashioning either environmental or energy policies that are well-suited to achieving the goal of mitigating human-induced climate change.

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[251] Emanuel et al., *Statement on the U.S. Hurricane Problem* (July 25, 2006), *available at* http://wind.mit.edu/~emanuel/Hurricane_threat.htm. The statement also warned that "the more urgent problem of our lemming-like march to the sea requires immediate and sustained attention. We call upon leaders of government and industry to undertake a comprehensive evaluation of building practices, and insurance, land use, and disaster relief policies that currently serve to promote an ever-increasing vulnerability to hurricanes." *Id*.

[252] For a description of the some of the many adverse health, environmental, economic, and social effects that global climate change is already having and may have in the future, see ROBERT L. GLICKSMAN ET AL., ENVIRONMENTAL PROTECTION: LAW AND POLICY ___-___ (5th ed. 2007) (forthcoming).

[253] *See, e.g.*, Witze, *Bad Weather*, *supra* note 50 (asserting that "the stakes could not be higher. Knowing where and how often storms might strike is crucial for shaping government policies."); LLNL News Release, *supra* note 85 (stating that "[i]n the real world, we're performing an uncontrolled experiment by burning fossil fuels and releasing greenhouse gases").

It behooves those interested in the welfare of the residents of areas at risk from category 4 or 5 hurricanes or from coastal flooding to press public policymakers at all levels of government to take immediate steps to mitigate the risks of climate-related damage that might result from further warming of the earth's air and oceans. The pitfalls of failing to take adequate precautions are ominously clear. More than a year after Katrina, the devastation wrought by the storm and the flooding associated with it in New Orleans and along the Mississippi Gulf Coast provides a constant reminder that the consequences of betting the house on the most benign climate change scenario may prove to be dire.[254] In particular, the federal government's do nothing (or next-to-nothing) approach to global climate change is no longer acceptable.

[254] *See, e.g.*, Witze, *supra* note 50 (arguing that "[f]or people living in vulnerable coastal regions, answers to the debates can't come soon enough. New Orleans is slowly being rebuilt with higher levees to keep storm surges out. And while researchers argue over the details of databases and data analysis, residents are girding for another six months of uncertainty.).