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Global Climate Change: Major Scientific and Policy Issues

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Summary

There is growing evidence that human activities are affecting the heat/energy-exchange balance between Earth, the atmosphere, and space through an increase in "greenhouse gases." If these gases continue to accumulate in the atmosphere at current rates, most scientists believe significant global warming would continue to occur through intensification of Earth's natural heat-trapping "greenhouse effect." Over the past 100 years, particularly in recent decades, there have been measurable increases in global temperature and sea levels, decreases of sea ice in the Arctic, and melting among the world's continental ice sheets and mountain glaciers. A preponderance of the world's scientists have concluded that human activities, particularly the burning of fossil fuels, have increased atmospheric concentrations of carbon dioxide (CO_2) by 36% from pre-industrial levels of 280 parts per million (ppm) to 380 ppm over the past 150 years, leading to an increase in global average temperature of 0.9°F over the past 100 years. There is broad agreement on those aspects of climate change, which have been measured and are reflected in global data. Disagreements focus mainly on the magnitude and rate of change, the severity of estimated warming, and its projected impacts — both positive and negative. Moreover, wide variations of scientific opinion accompany model projections of a warmer world: if these increases in greenhouse gas emissions continue, global average temperature could rise anywhere from 2.7°F to 10.7°F over the next 100 years. Because the U.S. economy is so dependent upon energy, and so much of U.S. and worldwide energy is derived from fossil fuels, options for reducing emissions of carbon dioxide and other greenhouse gases pose major challenges and controversy.

The basic policy question remains: Given scientific uncertainties about the magnitude, timing, rate, and regional consequences of potential climatic change, what are the appropriate responses for U.S. and world decision makers?

The 1992 United Nations Framework Convention on Climate Change (UNFCCC), ratified by the United States , called for a "non-binding," voluntary aim for industrialized countries to stabilize their emissions of greenhouse gases at 1990 levels by the year 2000. This was followed by the 1997 Kyoto Protocol to the UNFCCC, which commits the major industrialized nations that have ratified it to specified, legally binding emissions reductions. On February 16, 2005, the Kyoto Protocol entered into force without ratification by the United States. As of July 10, 2006, 164 nations and economic regional integration organizations had ratified the Protocol. In March 2001, the Bush Administration rejected the Kyoto Protocol, and thus the United States is not party to it (and therefore is not subject to its requirements). President Bush concluded a cabinet-level climate policy review with an announcement in 2002 of a "new approach" for the United States based on reducing the greenhouse gas intensity (greenhouse gas emissions per unit of GDP) of the U.S. economy.

This report briefly reviews the status of climate science, international negotiations, and congressional activity focused specifically on climate change. It replaces CRS Issue Brief IB89005.

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Global Climate Change: Major Scientific and Policy Issues

The measurable increase in average global temperatures, termed "global warming" and linked to increases in "greenhouse" gases in the Earth's atmosphere, has led to international efforts to achieve reductions of emissions of those gases from human activities, as well as domestic debates in the United States concerning the appropriate policies to address related concerns. This report briefly reviews the status of scientific research on the underpinnings of global climate change, and briefly outlines both international action and domestic policies, including legislation in the 109th Congress to address climate change.

Global Climate Change Science

A preponderance of the world's scientists have concluded that human activities have contributed to increased atmospheric concentrations of carbon dioxide (CO_2) by 36% from pre-industrial values of 280 parts per million (ppm) to 380 ppm over the past 150 years, leading to an increase in global average temperatures. Global temperatures have already risen 0.6°C (0.9°F) in the last 100 years, and, according to model projections, might rise anywhere from as little as 1.8°C to as much as 7.1°C (2.7°F to 10.7°F) over the next 100 years. However, the science of climate change is not without challengers, who argue that scientific proof is incomplete or contradictory, and that there remain many uncertainties about the nature and direction of Earth's future climate state. Nevertheless, there is significant concern that human activities, such as the burning of fossil fuels, industrial production, deforestation, and certain land-use practices, are increasing atmospheric concentrations of carbon dioxide (CO_2) that, along with increasing concentrations of other trace gases such as methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), may be leading to changes in the chemical composition and physical dynamics of Earth's atmosphere, including how heat/energy is distributed between land, ocean, atmosphere, and space.

Greenhouse Gases: Sources and Trends

Scientists have found that the four most important variable greenhouse gases, whose atmospheric concentrations can be influenced by human activities, are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and chlorofluorocarbons (CFCs). Historically, CO_2 — which is produced when fossil fuels are burned — has been the most important, but those other atmospheric trace gases are also radiatively active, in that they can affect Earth's heat budget and thereby contribute to a greenhouse warming of the lower atmosphere.

The amount of carbon cycling from naturally occurring processes each year through the biosphere as CO_2 is enormous — some 800 billion tons. Ice cores and other proxy climate data, which also indicate CO_2 concentrations in the atmosphere, have shown, in general, a relatively stable global climate, at least over the past 10,000 years. As such, many scientists suggest that the amount of CO_2 generated by natural processes is about equal to the amounts absorbed and sequestered by natural processes. However, human activity since the Industrial Revolution (ca. 1850), primarily in the form of burning fossil fuels, is now generating some additional 24 billion tons of CO_2 per year. Available evidence shows that about half this amount is absorbed by natural processes on land and in the ocean, and that atmospheric concentrations of CO_2 are currently about 36% higher at 380 parts per million (ppm) than they were some 150 years ago at 280 ppm. Some scientists believe that a large amount of CO_2 may be stored in northern latitude soils and in temperate and tropical forests, suggesting a greater importance of the role of natural resources management and land-use practices in these regions, including burning of biomass and deforestation. Scientists estimate that anthropogenic emissions of CO_2 alone may account for as much as 60% of the increase in global mean temperatures of 0.9°F, since 1850.

The combined radiative forcing[1] from the other trace gases is approximately equal to that of CO_2 and, collectively, they are projected to contribute about as much to potential global warming over the next 60 years as CO_2. Some of the halogenated compounds, while present in the atmosphere at very low concentrations, are of considerable interest because of their high global warming potentials (GWPs) and long atmospheric residence times. Methane concentrations had been rising from a preindustrial value of around 700 parts per billion (ppb) up to the mid-1990s, when they began to level off to a present value of about 1,766 ppb, a 152% increase. Nitrous oxide concentrations have been rising from a preindustrial value of around 270 parts per billion (ppb) up to a present value of about 317 ppb, representing a 17% increase.

The atmospheric concentrations of the chlorofluorocarbons CFC-11, at 268 parts per trillion (ppt), and CFC-113, at 84 ppt, have been on the decline in recent years in response to the Montreal Protocol of the late 1980s.[2] The concentration of CFC-12 at 533 ppt is also anticipated to decline, but the decline is expected to be delayed due to (1) a longer atmospheric lifetime than CFC-11 or CFC-113, (2) its use in long-lasting appliances such as home refrigerators, and possibly (3) particularly extensive stockpiling at the global scale, due to a perceived lack of suitable

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[1] As a general concept, the term radiative forcing in climate science means any change in the radiation (heat) entering or leaving the climate system. It can be due to changes in sunlight arriving, or to differing amounts of radiatively active gases. A positive forcing tends to warm the system while a negative forcing tends to cool it.

[2] The Montreal Protocol on Substances That Deplete the Ozone Layer was a landmark international agreement designed to protect the stratospheric ozone layer. The treaty was originally signed in 1987 and substantially amended in 1990 and 1992. The Montreal Protocol stipulated that the production and consumption of compounds that deplete ozone in the stratosphere — chlorofluorocarbons (CFCs), halons, carbon tetrachloride, and methyl chloroform — were to be phased out by 2000.

replacement at the time production decreases were being mandated. The Kyoto Protocol on Climate Change (discussed in detail in the section on "U.N. Framework Convention on Climate Change") also regulates three other trace gases: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), whose limited concentrations in the atmosphere are anticipated to grow over the long term. Sulfate aerosols, a byproduct of air pollution, and other natural phenomena are also viewed as important for their transient and regional "climate cooling" effects in Earth's atmosphere.

On a related note, NASA scientist James Hansen has suggested that Earth's climate could benefit from near-term regulation of non-CO_2 greenhouse gases. He proposed that reducing emissions of halocarbons (refrigerants), methane, nitrogen oxides, and carbon-black aerosols (soot) could have the effect of reducing ozone, itself a greenhouse gas, in the troposphere. Non-CO_2 greenhouse gases have relatively short atmospheric lifetimes compared with CO_2; however, most have a much larger global warming potential (gwp). This would suggest that controlling emissions of these greenhouse gases could reduce the rate and overall amount of potential climate warming from greenhouse gases, leaving only that projected from long-term CO_2 emissions whose full effects might not be realized for another 75-100 years. Nevertheless, Hansen emphasized that any actions to reduce emissions of these gases would need to be taken concomitantly with long-term strategies to reduce CO_2. Hansen also noted that modest gains from reducing CO_2 and non-CO_2 emissions in the near term could be achieved primarily through cleaner energy production.[3]

Climate System Response

The most recent runs of state-of-the-art computer models of the Earth's climate (general circulation models, or GCMs) have projected a globally averaged warming ranging from almost 3°F to 10.7°F over the next 100 years, if greenhouse gases continue to accumulate in the atmosphere at the current rate. Many climate scientists believe that such a warming could shift temperature zones, rainfall patterns, and agricultural belts and, under certain scenarios, cause sea level to rise. With regard to sea level rise, over the last 100 years, the global sea level has risen by about 10 to 25 centimeters (4 to 10 inches). It is likely that much of the rise in sea level has been related to the concurrent rise in global temperature over the last 100 years. On this time scale, the warming and the consequent thermal expansion of the world ocean may account for about 0.8 to 3 inches of the observed sea level rise, while the observed retreat of glaciers and ice caps may account for about 0.8 to 2 inches.

Other factors are more difficult to quantify, including isostatic effects associated with rising or subsiding coastlines, neotectonics, and sedimentation. The rate of observed sea level rise suggests a net positive contribution from the huge ice sheets of Greenland and Antarctica, but observations of the ice sheets do not yet allow meaningful quantitative estimates of their separate contributions. The ice sheets

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[3] See Dr. Hansen's research article, *Global Warming in the 21st Century: An Alternative Scenario*, on the website maintained by the NASA Goddard Institute for Space Studies at [http://www.giss.nasa.gov/research/features/altscenario/] .

remain a major source of uncertainty in accounting for past changes in sea level because of insufficient data about them over the last 100 years. Taking into account the ranges in the estimate of climate sensitivity and ice melt parameters, and the full set of greenhouse gas emissions scenarios, the models project an increase in global mean sea level of between 5 and 37 inches by the year 2100. In addition, because of the thermal inertia of the oceans, sea level could continue to rise for many centuries beyond 2100 even if concentrations of greenhouse gases were stabilized at that time. Some climate scientists further project that global warming could have far-reaching effects — some positive, some negative, depending how it may be experienced in a given region — on natural resources; ecosystems; food and fiber production; energy supply, use, and distribution; transportation; land use; water supply and control; and human health.

Skeptics of the global warming theory have called into question the reliability of the computer climate models and their output used to make projections of future warming that supported Kyoto Protocol negotiations. They also challenge some scientists' assertions that recent episodic weather events may seem more extreme in nature, and that this may be indicative of long-term climate change.

Evidence of natural variability of climate is large enough that even the record-setting warmth at the end of the 20th century has made it difficult for many climate scientists to state beyond a reasonable doubt that weather extremes experienced over the past two decades are attributable to "global warming," at least at the present time. However, the warming trend at the surface appears to be continuing. In some cases, causal relationships between seasonal and inter-annual climate variability and present-day severe weather events are beginning to be recognized and even predicted, owing to an improved ability to observe such phenomena as *El Nino* and *La Nina*, the North Atlantic Oscillation (NAO), and the Pacific Decadal Oscillation (PDO). That notwithstanding, singular extreme weather events have focused public, academic, and government attention on possible outcomes of potential long-term climate change and a need for a better understanding of regional climates on decadal to century time scales.

National Oceanic and Atmospheric Administration's (NOAA) researchers reported that the 12 warmest years (globally averaged) since historical records have been kept occurred in the past two decades, with 1990 and 1998 among the warmest. Those records reveal the year 2005 as being slightly warmer than 1998. At least some of this warming, they concluded, is human-induced. In fact, according to a report of the National Research Council released June 22, 2006,[4] there is sufficient evidence from tree rings, retreating glaciers, and other "proxies" to say with confidence that the last few decades of the 20th century were warmer than any comparable period in the last 400 years; however, there is less confidence in reconstructions of surface temperatures from 1600 back to A.D. 900, and very little confidence in findings on average temperatures before then.

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[4] National Research Council, Board on Atmospheric Sciences and Climate, Committee on Surface Temperature Reconstructions for the Last 2,000 Years, *Surface Temperature Reconstructions for the Last 2,000 Years* (Washington, DC: The National Academies Press, 2006), 141 pp.

On the other hand, satellite instruments — which, through indirect methods, measure the average temperature of the atmosphere in a deep column above the surface — have not demonstrated any positive warming trend over the past 20-year period, at least until very recently. A report issued in 2000 by the U.S. National Research Council's Board on Atmospheric Sciences and Climate, *Reconciling Observations of Global Temperature Change*,[5] attempted to resolve apparent disparities between temperature data measured at the surface and those from satellites. Scientists who question the surface temperature record state that such disparate trends invalidate the output of general circulation models (GCMs), many of which demonstrate homogenous warming throughout all the levels of the Earth's atmosphere. Panel scientists concluded that there may be a systematic disconnect between the upper and near surface atmosphere and cited physical processes not currently accounted for in GCMs that may have a unique impact on the upper atmosphere. In addition, they acknowledged that only long-term, systematic monitoring of the upper atmosphere could resolve the differences in temperature trends.

Scientific work continues in the opposing communities and among government and university modeling centers, accompanied by analysis of weather balloon and radiosonde data and re-analysis of surface temperature and satellite data sets, with the prospect of advancing resolution of this pivotal issue. The most recent entry into this fray, released May 2, 2006, by the U.S. Climate Change Science Program (CCSP), is the first of what will be 21 Synthesis and Assessment Products, this one entitled *Temperature Trends in the Lower Atmosphere — Steps for Understanding and Reconciling Differences; CCSP Synthesis and Assessment Product 1.1*.[6] As the CCSP report recounts the argument: Surface data showed substantial global-average warming, while early versions of satellite and radiosonde data showed little or no warming above the surface. According to the CCSP report, however, this significant discrepancy no longer exists because errors in the satellite and radiosonde data have been identified and corrected. New data sets have also been developed that do not show such discrepancies. At the present time, this Synthesis and Assessment Product is an important revision to the conclusions of earlier reports from the U.S. National Research Council (2000) and the Intergovernmental Panel on Climate Change (2001). For recent decades, all current atmospheric data sets now show global-average warming that is similar to the surface warming. While those data are consistent with the results from climate models at the global scale, discrepancies in the tropics still remain to be resolved.

The Intergovernmental Panel on Climate Change (IPCC), jointly established in 1988 by the United Nations World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP), reported in its *Second Assessment* (1996) that "[such] a change is unlikely to be entirely natural in origin ... [and that] the balance of evidence, from changes in global mean surface air temperature and

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[5] National Research Council, Climate Research Committee, Panel on Reconciling Temperature Observations, *Reconciling Observations of Global Temperature Change* (Washington, DC: National Academies Press, 2000), 104 pp.

[6] This report may be viewed in PDF format on the U.S. Climate Change Science Program website at [http://www.climatescience.gov/Library/sap/sap1-1/finalreport/default.htm].

from changes in geographical, seasonal, and vertical patterns of atmospheric temperature, suggests a discernible human influence on global climate."[7] Issuing an updated conclusion in January 2001, the Intergovernmental Panel in its *Third Assessment* (2001) reported that a firmer association between human activities and climate seemed to have emerged, stating that "in the light of new evidence and improved understanding, and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations."[8] That was news, because reservations about the source of the past century's warming and whether it bore a human fingerprint are often cited in policy debates, usually in support of deferring actions aimed at mitigating possible global warming. In addition, the IPCC reported a higher range of potential warming — roughly between 2.7°F and just under 11°F over the next 100 years.

In the United States, the national assessment report *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, released in November 2000 to the President and the Congress and published under the auspices of the U.S. Global Research Program, received criticism from many of those involved in its review. Critics claimed that many of the model-projected impacts of possible future climate changes were overstated and unsubstantiated. Additional criticism was leveled at the national assessment report because it was produced by a National Assessment Synthesis Team, an advisory committee chartered under the Federal Advisory Committee Act. As such, the report was not subjected to Office of Science and Technology Policy and Office of Management and Budget standards for government-issued reports mandated by Information Quality Act Guidelines. The National Assessment Synthesis Team (NAST), with overall authority for the report, countered that much of the criticism it had received did not take into account the time scales upon which the report was based; the report targeted the effects of climate toward the middle of this century to the end of the next. Also, seemingly contradictory outcomes were produced by the two climate models selected for making the climate projections, casting some lingering doubt on the overall value and utility of the results for decision makers at the local, regional, and national levels. The full national assessment, plus various regional and resource-focused assessments are now available at the website maintained by the U.S. Global Change Research Program.[9]

On June 6, 2001, a Committee on the Science of Climate Change of the U.S. National Research Council (NRC) released a report, *Climate Change Science: An Analysis of Some Key Questions*, stating that global warming could well have serious societal and ecological impacts by the end of this century.[10] Commissioned by the

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[7] The IPCC First (1990), Second (1995), and Third (2001) Assessments and IPCC Special Reports appear in PDF format on the IPCC website at [http://www.ipcc.ch/pub/reports.htm].

[8] Ibid.

[9] The *National Assessment* reports may be viewed in PDF format on the U.S. Global Change Research Program website at [http://www.usgcrp.gov/usgcrp/nacc/default.htm].

[10] National Research Council, Committee on the Science of Climate Change, *Climate* (continued...)

Bush White House and prepared by 11 of the nation's leading climate scientists, the report summarized the current state of knowledge on climate change and confirmed that the climatic changes observed during the past several decades were most likely due to human activities. The committee members warned, however, that they could not rule out the possibility that the climate's natural variability could be responsible for a significant portion of that trend. The authors agreed that human-induced warming and sea level rise were expected to continue through the 21st century and beyond, but they emphasized that current predictions of the magnitude and rate of future warming "should be regarded as tentative and subject to future adjustments (either upward or downward)."

The NRC report generally concurred with the latest conclusions of the Intergovernmental Panel on Climate Change, which found that the Earth warmed by about 1°F during the 20th century, and that most of the warming of the past 50 years was probably due to increases in greenhouse gas concentrations in the atmosphere.

President Bush made a speech on global climate change from the Rose Garden on June 11, 2001, following release of that NRC *Key Questions* report and completion of a cabinet-level review of climate change options. In that speech, timed just before his trip to Europe to meet with leaders there, the President acknowledged that the world has warmed and that greenhouse gases have increased, largely due to human activity, but emphasized that the magnitude and rate of future warming are unknown.

The Policy Context

Since the conclusion of the United Nations Framework Convention on Climate Change (UNFCCC) at the Earth Summit in Rio de Janeiro in 1992, U.S. climate policy has been evolving through several different stages, first under the Clinton Administration, and then under a very different approach taken by the Bush Administration. This history is reviewed briefly below. (For more information on U.S. Climate Policy and how it has developed, see CRS Report RL31931, *Climate Change: Federal Laws and Policies Related to Greenhouse Gas Reductions.)*

Clinton Administration Policies. Taking office the year after the UNFCCC was completed, the Clinton Administration presided over early U.S. efforts to deal internationally with climate change, and to participate in formulation of the Kyoto Protocol to the UNFCCC. On October 19, 1993, President Clinton released his *Climate Change Action Plan* (CCAP), which proposed voluntary domestic measures to attain greenhouse gas emissions stabilization as outlined by the UNFCCC**,** to stabilize U.S. emissions at 1990 levels by the year 2000.[11] The CCAP called for comprehensive voluntary measures by industry, utilities, and other large-scale energy users. CCAP stressed energy-efficiency upgrades through new building codes in

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[10] (...continued)
Change Science: An Analysis of Some Key Questions (Washington, DC: National Academy Press, 2001), 42 pp.

[11] This plan may be viewed in HTML format on a website maintained by the U.S. Global Change Research Information Office (GCRIO) at [http://gcrio.gcrio.org/USCCAP/toc.html].

residential and commercial sectors, and other improvements in energy-generating or -using technologies. Large-scale tree planting and forest reserves were encouraged to enhance sequestration of carbon dioxide and to conserve energy. Other aspects of the plan addressed mitigation of greenhouse gases other than CO_2. The CCAP avoided mandatory command and control measures.

On November 12, 1998, President Clinton instructed a representative to sign the legally binding Kyoto Protocol that established mandatory reductions in greenhouse gas emissions for the 38 industrialized nations in Annex I of the UNFCCC. This drew protest by some in Congress. Some Members claimed Clinton action was in violation of the June 1997 Byrd/Hagel Resolution (S.Res.98) that required an economic analysis of legally binding emission reductions on the United States, as well as binding obligations for all UNFCCC parties, including developing countries. The President announced he would continue to pursue "meaningful" commitments from key developing countries — which have no binding obligations to reduce or restrain greenhouse gas emissions under the Kyoto Protocol — before he would send the treaty to the Senate for advice and consent (which is required to enable U.S. ratification of any treaty).

The Clinton Administration released an economic analysis in July 1998, prepared by the Council of Economic Advisors, that concluded that with emissions trading among the Annex B/Annex I countries, and participation of key developing countries in the "Clean Development Mechanism" — which grants the latter business-as-usual emissions rates through 2012 — the costs of implementing the Kyoto Protocol could be reduced as much as 60% from many estimates.[12] Other economic analyses, however, prepared by the Congressional Budget Office and the DOE Energy Information Administration (EIA), and others, projected a potentially large declines in GDP from implementing the Protocol.

On November 11, 2000, President Clinton issued a statement on "Meeting the Challenge of Global Warming" in response to the results of the report *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*.[13] In his statement, President Clinton said his Administration would promulgate new regulations for U.S. electric power plants, imposing emissions caps on sulphur, nitrogen oxides, mercury, and CO_2. He also called for establishment of a domestic emissions trading program and promised a continued U.S. leadership role in climate change to set an example for other industrialized countries. President Clinton announced he would take such steps as necessary to keep the United States on target for meeting Kyoto Protocol goals, if certain concessions were made regarding international adoption of flexible mechanisms such as emissions trading, the clean development mechanism (CDM), credit for carbon sinks, and accountable, legally-binding, compliance mechanisms.

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[12] U.S., Executive Office of the President, President's Council of Economic Advisers, *The Kyoto Protocol and the President's Policies to Address Climate Change: Administration Economic Analysis*, prepared for the Council by the Interagency Analytical Team, Washington, July 1998 (various pagings).

[13] Footnote 9, op.cit.

Bush Administration Policies. Soon after taking office, the Bush Administration had asked for a delay in resumption of the negotiations that had collapsed in November 2000 at the Sixth Conference of the Parties to the U.N. Framework Convention on Climate Change (see COP-6 discussion later in this report), in order to allow time for consideration of its approach and policies. Talks were accordingly scheduled for the second half of July 2001. However, in late March 2001, the Bush Administration rejected the Kyoto Protocol — causing widespread dismay among the nations of the European Union — citing lack of developing country participation and possible harm to the U.S. economy. This followed extensive press attention to, first, statements by the EPA Administrator that — pursuant to her understanding of a campaign statement by then-candidate George W. Bush — carbon dioxide would be included in a multi-pollutant regulatory effort; and then a repudiation of that position and clarification by President Bush and Administration spokespersons that carbon dioxide would not be regulated.

President Bush made a policy statement in mid-June 2001, resulting from a continuing cabinet-level review of climate change options, in which he outlined the U.S. approach as rejecting the Kyoto Protocol and favoring voluntary actions, increased scientific research, and market mechanisms. As noted above, this preceded his trip to Europe for meetings with European heads of state, which ended with statements that Europe and the United States "agree to disagree" on climate change approaches. President Bush also outlined a Climate Change Research Initiative (CCRI) and a National Climate Change Technology Initiative (NCCTI), along with a new Cabinet-level Committee on Climate Change Science and Technology Integration to oversee their implementation. The CCRI and the NCCTI focus on short-term, policy-relevant objectives of climate change science and climate change technology applications, respectively. A previously established U.S. Global Change Research Program (USGCRP) supports long-term, fundamental, scientific research objectives, and a Climate Change Technology Program (CCTP) supports the federal government's broader portfolio of climate change technology R&D.

Both the new CCRI and the existing USGCRP were combined for the first time into the Climate Change Science Program (CCSP) in the FY2004 budget. The FY2007 budget requested a total spending level of $1.717 billion for research managed by the CCSP, which is $4 million (+0.2%) above the FY2006 funding estimate of $1.713 billion. Included in the $1.717 billion CCSP funds are $200 million for the CCRI. While funding for the embedded CCRI experienced growth over two fiscal years from FY2003 to FY2005, the FY2007 funding request for CCRI at $200 million is level with the FY2006 funding estimate of $200 million. That leaves the FY2007 funding requested for the embedded USGCRP standing at $1.517 billion, which is $4 million (+0.3%) above the FY2006 funding estimate of $1.513 billion. Some $2.98 billion is in the requested FY2007 funding profile for technology research and development in the Climate Change Technology Program(CCTP) and its embedded NCCTI, an amount $207 million (+7.5%) above the FY2006 funding level of $2.773 billion.

Two issues of concern to Congress are the extent to which spending for the CCRI and CCTP represents new money, versus how much is attributable to the reclassification of ongoing research and technology programs, and whether reduced funding in some cases, or virtually level funding in most other cases, might be

deemed necessary or sufficient to accomplish the work of the CCSP and the CCTP. Five reports currently serve as guidance documents for CCSP and CCTP activities. The Administration released a *Climate Change Science Program Strategic Plan* on July 24, 2003.[14] The plan included five major research goals and dozens of specific research targets as well as 23 written synthesis and assessment products with deadlines. The National Research Council of the National Academy of Sciences conducted an independent review of the *CCSP Strategic Plan* and in April 2004 published its overall assessment in a 51-page report, *Implementing Climate and Global Change Research: A Review of the Final U.S. Climate Change Science Program Strategic Plan*.[15] To complement the *CCSP Strategic Plan*, the Department of Energy has released four guidance documents for Climate Change Technology Program activities: *Results of a Technical Review of the U.S. Climate Change Technology Program's R&D Portfolio* (May 2006), *Climate Change Technology Program Strategic Plan Public Review Draft* (January 2006), *U.S. Climate Change Technology Program: Technology Options for the Near and Long Term* (September 2005), and *U.S. Climate Change Technology Program: Vision and Framework for Strategy and Planning* (August 2005).[16] Release by the CCTP of the completed final *Strategic Plan on Climate Change Technology* is expected late in 2006.

In June 2001, the Europeans announced their intentions to proceed with ratification of the Kyoto Protocol, while President Bush indicated the United States would continue to participate in negotiations of the UNFCCC parties in order to pursue its own objectives, but would not participate directly in Kyoto Protocol negotiations. When talks resumed among UNFCCC parties at "COP-6 resumed" in mid-July in Bonn, Germany, and continued in the fall of 2001 in Marrakech, Morocco at COP-7, the United States delegation did not make new proposals and declined to participate in negotiations on issues of the Kyoto Protocol. Agreement among the other parties was found on the remaining Protocol issues at COP-7, and they announced that they would seek ratification of the Kyoto Protocol, and its entry into force — even without the participation of the United States.

On February 14, 2002, apparently concluding the cabinet-level review of climate change underway since early 2001, President Bush announced a U.S. policy for climate change: a "new approach for meeting the long-term challenge of climate change."[17] The centerpiece of this announcement was the plan to reduce greenhouse

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[14] The *Strategic Plan* may be viewed in PDF format on a website maintained by the U.S. Climate Change Science Program at [http://www.climatescience.gov/Library/stratplan2003/default.htm]

[15] National Research Council, Committee to Review the U.S. Climate Change Science Program Strategic Plan, *Implementing Climate and Global Change Research: A Review of the Final U.S. Climate Change Science Program Strategic Plan* (Washington, The National Academies Press, 2004), 51 pp.

[16] Each of these four technology reports may be viewed in PDF format on a website maintained by the U.S. Climate Change Technology Program at [http://www.climatetechnology.gov/].

[17] "President Announces Clear Skies & Global Climate Change Initiatives," remarks during a visit February 14, 2002, to the National Oceanic and Atmospheric Administration campus

(continued...)

gas intensity of the U.S. economy by 18% over the next 10 years. Greenhouse gas intensity measures the ratio of greenhouse gas emissions to economic output, and has been declining in the United States over the past several years. The Administration stated that the goal, to be met through voluntary action, is to achieve efficiency improvements that would reduce the 183 metric tons of emissions per million dollars of gross domestic product (GDP) expected under "business as usual" to 151 metric tons in 2012. The plan noted that "if, in 2012, we find that we are not on track toward meeting our goal, and sound science justifies further policy action, the United States will respond with additional measures that may include a broad, market-based program" and other incentives and voluntary measures to accelerate technology development.

In addition, the policy directed the Secretary of Energy, in consultation with other key agencies, to "substantially improve the emission reduction registry" to upgrade the voluntary emission reduction program under Section 1605(b) of the 1992 Energy Policy Act, to bring about enhanced measurement accuracy, reliability, and verifiability. Other measures included providing for protected, transferable emission reduction credits, increased funding of $700 million in total climate-related spending, and a new management structure to coordinate climate change and technology research. Domestic policies such as tax incentives for renewable energy and new technology, development of fuel-efficient vehicles and cleaner fuels, and carbon sequestration were also proposed, along with several international bilateral initiatives and relatively modest increases in foreign assistance.

Some observers praised the plan for taking a practical, conservative approach to government action and for relying on voluntary measures. Critics observed that voluntary approaches by themselves have not historically often been effective, and noted that the reductions in energy intensity are very little different from current trends and would allow for significant increases in overall greenhouse gas emissions rather than reductions.

Continuing to encourage voluntary action rather than mandatory requirements, the Administration detailed on February 12, 2003, a set of voluntary agreements by various industry groups under an umbrella initiative titled Climate VISION (Voluntary, Innovative Sector Initiatives: Opportunities Now). These initiatives by sectoral groups involve actions to reduce greenhouse gas emissions and improve energy efficiency.[18]

International Action

The United States was involved in negotiations and international scientific research on climate change prior to ratifying the 1992 U.N. Framework Convention

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[17] (...continued)
in Silver Spring, Maryland. Remarks and fact sheet may be viewed on the White House website at [http://www.whitehouse.gov/news/releases/2002/02/20020214-5.html].

[18] For a fuller description, see the "Global Climate Change Policy Book" on the White House website at [http://www.whitehouse.gov/news/releases/2002/02/climatechange.html].

on Climate Change (UNFCCC). This included passage of a National Climate Program Act of 1978 (P.L. 95-367). (These activities are discussed in CRS Report RL30522, *Global Climate Change: A Survey of Scientific Research and Policy Reports*, which covers early aspects of the scientific debate and contains a chronology of U.S. government involvement in climate change policy before 1992.)

U.N. Framework Convention on Climate Change (UNFCCC)[19]

The United Nations Framework Convention on Climate Change (UNFCCC) was opened for signature at the 1992 United Nations Conference on Environment and Development (UNCED) conference in Rio de Janeiro (known by its popular title, the Earth Summit). On June 12, 1992, the United States, along with 153 other nations, signed the UNFCCC, that upon ratification committed signatories' governments to a voluntary "non-binding aim" to reduce atmospheric concentrations of greenhouse gases with the goal of "preventing dangerous anthropogenic interference with Earth's climate system." These actions were aimed primarily at industrialized countries, with the intention of stabilizing their emissions of greenhouse gases at 1990 levels by the year 2000; and other responsibilities would be incumbent upon all UNFCCC parties. The parties agreed in general that they would recognize "common but differentiated responsibilities," with greater responsibility for reducing greenhouse gas emissions in the near term on the part of developed/industrialized countries, which were listed and identified in Annex I of the UNFCCC and thereafter referred to as "Annex I" countries.

On September 8, 1992, then-President George H. W. Bush transmitted the UNFCCC for advice and consent of the U.S. Senate to ratification. The Foreign Relations Committee approved the treaty and reported it (Senate Exec. Rept. 102-55) October 1, 1992. The Senate consented to ratification on October 7, 1992, with a two-thirds majority vote. President Bush signed the instrument of ratification October 13, 1992, and deposited it with the U.N. Secretary General. According to terms of the UNFCCC, having received over 50 countries' instruments of ratification, it entered into force March 24, 1994.

Since the UNFCCC entered into force, the parties have been meeting annually in conferences of the parties (COP) to assess progress in dealing with climate change, and beginning in the mid-1990's, to negotiate the Kyoto Protocol to establish legally binding obligations for developed countries to reduce their greenhouse gas emissions. After completion of the Protocol in 1997, COP meetings focused on formulating the operational rules that would prevail as nations attempted to meet their obligations to reduce emissions. These rules were essentially agreed upon at COP-7 (see below) in 2001. A number of difficult issues were under discussion at these annual meetings, including how emissions trading rules would be set, how to count elements in a nation that absorb carbon (carbon "sinks") such as forests, and the continuing question of "next steps" that might focus on how to proceed in the period following

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[19] For current information, status of ratification of the Kyoto Protocol, and extensive background on the UNFCCC and the annual meetings of the UNFCCC parties, see the Secretariat website at [http://www.unfccc.int].

the year 2012, which concludes the "commitment period" during which emissions reductions were to be achieved by those countries with reduction obligations. (For detailed discussion of the key issues being negotiated at these annual meetings, see CRS Report RL30692, *Global Climate Change: The Kyoto Protocol.*)

On February 16, 2005, the Kyoto Protocol entered into force. At that time, 141 nations had ratified it, including 35 of the 38 Annex B industrialized countries. Those Annex B parties to the UNFCCC that have ratified the Kyoto Protocol continue to express hope that the United States will re-engage in international efforts to reduce greenhouse gas emissions. As of July 10, 2006, some 164 nations had ratified or accepted the Kyoto Protocol.

COP-1, The Berlin Mandate

The UNFCCC Conference of Parties met for the first time in Berlin, Germany in the spring of 1995, and voiced concerns about the adequacy of countries' abilities to meet commitments under the Convention. These were expressed in a U.N. ministerial declaration known as the "Berlin Mandate," which established a two-year Analytical and Assessment Phase (AAP), to negotiate a "comprehensive menu of actions" for countries to pick from and choose future options to address climate change which for them, individually, made the best economic and environmental sense. The Berlin Mandate exempted non-Annex I countries from additional binding obligations, in keeping with the principle of "common but differentiated responsibilities" established in the UNFCCC — even though, collectively, the larger, newly industrializing countries were expected to be the world's largest emitters of greenhouse gas emissions 15 years hence.

COP-2, Geneva, Switzerland

The Second Conference of Parties to the UNFCCC (COP-2) met in July 1996 in Geneva, Switzerland. Its Ministerial Declaration was adopted July 18, 1996, and reflected a U.S. position statement presented by Timothy Wirth, former Under Secretary for Global Affairs for the U.S. State Department at that meeting, which (1) accepted the scientific findings on climate change proffered by the Intergovernmental Panel on Climate Change (IPCC) in its second assessment (1995); (2) rejected uniform "harmonized policies" in favor of flexibility; and (3) called for "legally binding mid-term targets."

COP-3, The Kyoto Protocol on Climate Change

The Kyoto Protocol to the United Nations Framework Convention on Climate Change was adopted by COP-3, in December 1997 in Kyoto, Japan, after intensive — and tense — negotiations. Most industrialized nations and some central European economies in transition (all defined as Annex B countries in the Protocol, a list that closely resembles Annex I of the UNFCCC) agreed to legally binding reductions in greenhouse gas emissions of an average of 6%-8% below 1990 levels in the years 2008-2012, defined as the first emissions budget period. The United States would be required to reduce its total emissions an average of 7% below 1990 levels. (For more details, see CRS Report RL30692, *Global Climate Change: The*

Kyoto Protocol.) The Protocol provided that it would enter into force when it had been ratified by 55 countries, accounting for 55% of developed country emissions in 1990. In 1997, prior to the completion of the Protocol, the U.S. Senate passed S.Res. 98, which urged the President not to agree to a treaty that did not include binding commitments for developing countries, or that would cause harm to the U.S. economy. As noted above, although President Clinton did sign the Protocol in 1998, it was never submitted by his administration to the Senate because it would not have met the conditions of S.Res. 98.

The Clinton Administration initiated funding efforts to address climate change; in the FY2001 budget request funding was included for a Climate Change Technology Initiative (CCTI) first introduced in his FY1999 budget. Somewhat reduced funding for the climate technology initiatives was provided through appropriations in previous years.

COP-4, Buenos Aires

COP-4 took place in Buenos Aires in November 1998. It had been expected that the remaining issues unresolved in Kyoto would be finalized at this meeting. However, the complexity and difficulty of finding agreement on these issues proved insurmountable, and instead the parties adopted a two-year "Plan of Action" to advance efforts and to devise mechanisms for implementing the Kyoto Protocol, to be completed by 2000.

COP-5, Bonn, Germany

The 5th Conference of Parties to the U.N. Framework Convention on Climate Change met in Bonn, Germany, between October 25 and November 4, 1998. It was primarily a technical meeting, and did not reach major conclusions.

COP-6, The Hague, Netherlands

When COP-6 convened November 13-25, 2000, in The Hague, Netherlands, discussions evolved rapidly into a high-level negotiation over the major political issues. These included major controversy over the United States' proposal to allow credit for carbon "sinks" in existing forests and on agricultural lands, satisfying a major proportion of the U.S. emissions reductions in this way; disagreements over consequences for non-compliance by countries that did not meet their emission reduction targets; and difficulties in resolving how developing countries could obtain financial assistance to deal with adverse effects of climate change and meet their obligations to plan for measuring and possibly reducing greenhouse gas emissions. In the final hours of COP-6, despite some compromises agreed between the United States and some EU countries, notably the United Kingdom, the EU countries as a whole, led by Denmark and Germany, rejected the compromise positions, and the talks in The Hague collapsed. Jan Pronk, the President of COP-6, suspended COP-6 without agreement, with the expectation that negotiations would later resume. It was later announced that the COP-6 meetings (termed "COP-6 bis") would be resumed in Bonn, Germany, in the second half of July. The next regularly scheduled meeting of the parties to the UNFCCC — COP-7 — had been set for Marrakech, Morocco,

in October-November 2001. (For more detailed discussion of COP-6 issues, see CRS Report RL30692, *Global Climate Change: The Kyoto Protocol.*)

COP-6 "bis," Bonn, Germany

When the COP-6 negotiations resumed July 16-27, 2001, in Bonn, Germany, little progress had been made on resolving the differences that had produced an impasse in The Hague. However, this meeting took place after President George Bush had become the U.S. President and had rejected the Kyoto Protocol in March. As a result, the U.S. delegation to this meeting declined to participate in the negotiations related to the Protocol, and chose to act as observers. As the other parties negotiated the key issues, agreement was reached on most of the major political issues, to the surprise of most observers given the low level of expectations that preceded the meeting. The agreements included:

(1) Mechanisms — the "flexibility" mechanisms which the United States had strongly favored as the Protocol was initially put together, including emissions trading; joint implementation; and the Clean Development Mechanism (CDM), which provides funding from developed countries for emissions reduction activities in developing countries, with credit for the donor countries. One of the key elements of this agreement was that there would be no quantitative limit on the credit a country could claim from use of these mechanisms, but that domestic action must constitute a significant element of the efforts of each Annex B country to meet their targets.

(2) Carbon sinks — credit was agreed to for broad activities that absorb carbon (carbon sinks) from the atmosphere or store it, including existing forest and cropland management, and revegetation, with no overall cap on the amount of credit a country could claim for sinks activities. In the case of forest management, an Appendix Z establishes country-specific caps for each Annex I country; for example, a cap of 13 million tons could be credited to Japan (which represents about 4% of its base-year emissions). For cropland management, countries could receive credit only for carbon sequestration increases above 1990 levels.

(3) Compliance — final action on compliance procedures and mechanisms that would address noncompliance with Protocol provisions was deferred to COP-7, but broad outlines of consequences for failing to meet emissions targets would include a requirement to "make up" shortfalls at 1.3 tons to 1; suspension of the right to sell credits for surplus emissions reductions; and a required compliance action plan for those not meeting their targets.

(4) Financing — three new funds were agreed upon to provide assistance for needs associated with climate change; a least-developed-country fund to support National Adaptation Programs of Action; and a Kyoto Protocol adaptation fund supported by a CDM levy and voluntary contributions.

A number of operational details attendant upon these decisions remained to be negotiated and agreed upon; these were the major issues of the COP-7 meeting that followed.

COP-7, Marrakech, Morocco

At the COP-7 meeting in Marrakech, Morocco, October 29-November 10, 2001, negotiators in effect completed the work of the Buenos Aires Plan of Action, finalizing most of the operational details and setting the stage for nations to ratify the Protocol. The United States delegation continued to act as observers, declining to participate in active negotiations. Other parties continued to express their hope that the United States would re-engage in the process at some point, but indicated their intention to seek ratification of the requisite number of countries to bring the Protocol into force (55 countries representing 55% of developed country emissions of carbon dioxide in 1990). A target date for bringing the Protocol into force was put forward — the August-September 2002 World Summit on Sustainable Development (WSSD) to be held in Johannesburg, South Africa — but this target was not met. The main decisions at COP-7 included operational rules for international emissions trading among parties to the Protocol and for the CDM and joint implementation; a compliance regime that outlines consequences for failure to meet emissions targets but defers to the parties to the Protocol after it is in force to decide whether these consequences are legally binding; accounting procedures for the flexibility mechanisms; and a decision to consider at COP-8 how to achieve a review of the adequacy of commitments that might move toward discussions of future developing country commitments.

COP-8 (New Delhi, India, 2002), COP-9 (Milan, Italy, 2003), COP-10 (Buenos Aires, 2004)

At these three meetings of the conference of parties to the UNFCCC, attempts were made to consider next steps after the 2008-2012 commitment period, but these attempts encountered resistance from developing countries and some other parties. The announced reluctance of Russia at the Milan COP-9 to undertake ratification of the Kyoto Protocol called into question whether or when the Protocol might enter into force. Without U.S. participation, the required 55% of baseline emissions of parties would not be achieved if Russia did not ratify. However, just before the COP-10 meeting, Russia did ratify the Protocol on November 18, 2004. Thus it became possible for the Kyoto Protocol to enter into force 90 days later, on February 16, 2005. All three of these meetings centered on largely technical issues, and avoided major substantive declarations; what "next steps" involving developing countries should be remained a controversial issue, and was not resolved.

COP-11, Montreal, Canada

COP-11 was held in Montreal, Canada, November 28 - December 9, 2005. This was a concurrent meeting — the 11th meeting of the parties to the UNFCCC, and the first meeting of the parties (MOP-1) to the Kyoto Protocol. One of the key outcomes of the Kyoto Protocol MOP was adoption of the "Marrakech Accords," which outline what the Secretariat terms the "rule book" for the Protocol. Among other things, it formally launches emissions trading by providing rules for trading, and outlines the operational rules for the Clean Development Mechanism and Joint Implementation, both of which provide for credit to developed countries for projects to reduce emissions or augment sinks in developing or other eligible countries. Other rules

adopted include how emissions are accounted for, guidelines on data systems needed, rules for a compliance system, and rules governing how absorption of carbon dioxide by agricultural soils and forests is to be measured. Discussions of "next steps" were considered under both the Protocol and the Convention. Negotiations under the Protocol were agreed upon that could lead to new binding commitments for Kyoto Protocol parties after 2012; and a decision under the Framework Convention was made to open a non-binding "dialogue on long-term cooperative action," which could include all parties to the Convention, including the United States.

Asia-Pacific Partnership on Clean Development and Climate

On July 27, 2005, a six-nation partnership was announced at the South East Asian Nations (ASEAN) forum — the Asia-Pacific Partnership on Clean Development and Climate (APP). This partnership agreement included six nations — the United States, Australia, China, India, Japan, and South Korea. The participants described the focus of the partnership as technology development and reduction of greenhouse gas intensity, with voluntary participation. Representatives of the six nations met in Sydney, Australia, in early January 2006, and spelled out the purpose and provided a work plan for the partnership in statements on January 12, 2006. The purposes that have been identified include to "Create a voluntary, non-legally binding framework for international cooperation to facilitate the development, diffusion, deployment, and transfer of existing, emerging and longer-term cost-effective, cleaner, more efficient technologies and practices among the Partners through concrete and substantial cooperation so as to achieve practical results." The charter for the partnership states: "The partnership will be consistent with and contribute to our efforts under the UNFCCC and will complement, but not replace, the Kyoto Protocol."[20]

Eight task forces were established to review the status of their sectors with regard to clean development and climate, to identify cost and performance objectives and realistic goals, and report on recommended actions within their sectors. The 8 sectors are: (1) Cleaner Fossil Energy, (2) Renewable Energy and Distributed Generation, (3) Power Generation and Transmission, (4) Steel, (5) Aluminum, (6) Cement, (7) Coal Mining, and (8) Buildings and Construction.

Congressional Interest and Activities

The prospect of global warming, and questions about what the United States could or should do about it have yielded, over the last several years, a range of legislative proposals in the U.S. Congress. Issues dealt with in bills that have been introduced in the 109th Congress include regulating emissions of carbon dioxide along with emissions of sulfur dioxide, nitrogen oxides, and mercury in so-called

[20] See a comprehensive Fact Sheet and other information on the APP at [http://www.asiapacificpartnership.org].

"multi-pollutant" legislation;[21] greenhouse gas reduction and carbon dioxide emissions trading systems;[22] energy issues relevant to climate change, especially those associated with encouraging or authorizing energy efficiency and alternative energy sources[23]; carbon sequestration technologies and methodologies; federal and national research concerning the prospect of abrupt climate change, climate change impacts, and climate system surprises; federal spending on climate change science programs and climate change technology programs and, more broadly, on global change monitoring and research programs; and long-term research and development programs to develop new technologies to help stabilize greenhouse gas emissions. (For an overview, summary, and comparison of key climate change legislation, see CRS Report RL32955, *Climate Change Legislation in the 109th Congress*.)

The Energy Policy Act of 2005 (P.L. 109-58), enacted in August 2005, included among its provisions programs to promote the development and deployment of technologies to reduce greenhouse gas intensity. The Senate voted to include a Sense of the Senate resolution — which was not included in the final legislation — stating that human activities are a substantial source of greenhouse gas accumulations in the atmosphere that are causing temperatures to increase, and that "Congress should enact a comprehensive and effective national program of mandatory market-based limits and incentives on greenhouse gases that slow, stop and reverse the growth of such emissions at a rate and in a manner that — (1) will not significantly harm the United States economy; and (2) will encourage comparable action by other nations that are major trading partners and key contributors to global emissions."[24]

On May 18, 2006, the House of Representatives in H.R. 5386, the FY2007 Interior-Environment appropriations bill, considered sense-of-the-Congress language, similar to that of the Senate, stating that there should be enacted a comprehensive and effective national program of mandatory, market-based limits and incentives on emissions of greenhouse gases that slow, stop, and reverse the growth of such emissions.[25] That language called for limits and incentives that did not significantly harm the U.S. economy and that would encourage comparable action by our major trading partners and key contributors to global emissions. The language was rejected, however, on a parliamentary point of order as constituting legislation in an appropriations bill, and, as such, violating clause 2 of rule XXI of House Rules.[26]

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[21] See CRS Report RL32755, *Air Quality: Multi-Pollutant Legislation in the 109th Congress*.

[22] See CRS Report RS21581, *Climate Change: Senate Proposals to Reduce Greenhouse Gas Emissions*; and CRS Report RS21067, *Global Climate Change: Controlling CO2 Emissions Cost-Limiting Safety Valves*.

[23] See CRS Report RL33588, *Renewable Energy Policy: Tax Credit, Budget, and Regulatory Issues*; and CRS Report RL33599, *Energy Efficiency Policy: Budget, Electricity Conservation, and Fuel Conservation Issues*.

[24] Section 1612 of the Senate version of H.R. 6.

[25] H.R. 5386, Title IV, Section 425, as reported in the House, H.Rept. 109-465.

[26] For the floor debate see pp. H2826-2829 in the May 18, 2006, daily edition of the *Congressional Record*, v. 152, no 62.

Congressional hearings on climate change in the 109th Congress included seven in the Senate by four committees: Commerce, Science and Transportation; Energy and Natural Resources; Environment and Public Works; and Foreign Relations. In the House, committee hearings included four hearings by three committees: Energy and Commerce; Government Reform; and Science. These were for the most part overview or oversight hearings, and were not focused on specific legislation.