NO. 05-1120

IN THE

Supreme Court of the United States

COMMONWEALTH OF MASSACHUSETTS, *et al.*
Petitioners,
v.
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,
Respondent.

ON WRIT OF CERTIORARI TO THE UNITED STATES
COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT

JOINT APPENDIX

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PETITION FOR CERTIORARI FILED MARCH 2, 2006
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10/23/03	PETITION FOR REVIEW CASE docketed. Petition for Review filed by Petitioner St CA, Petitioner CA Air Resrc Bd, Petitioner Bill Lockyer. [780992-1] (lme) [03-1362]
10/23/03	PETITION FOR REVIEW CASE docketed. Petition for Review filed by Petitioner Intl Ctr Technol, Petitioner Bluewater Ntwrk, Petitioner Ctr Bio Divrsty, Petitioner Ctr Food Sfty, Petitioner Consrvtn Law Fdn, Petitioner Env Advoc, Petitioner Env Def, Petitioner Friends Earth Inc, Petitioner Greenpeace, Petitioner Natl Env Trst, Petitioner Nat Resrc Def Cncl, Petitioner Sierra Club, Petitioner Union Cncnd, Petitioner US Pub Int Rsrch Grp. [781057-1] (lme) [03-1363]
10/23/03	PETITION FOR REVIEW CASE docketed. Petition for Review filed by Petitioner Mayor Balt City, Petitioner City NY, Petitioner City Cncl Balt. City [781095-1] (lme) [03-1364]

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12/23/03	CLERK'S ORDER filed [793023] of the respondent's unopposed motion to consolidate and to allow parties leave to file proposed briefing formats, it is ORDERED that the motion be granted [788499-1], and the above captioned cases are hereby consolidated. [Entry Date 12/23/03] [03-1361, 03-1362, 03-1363, 03-1364, 03-1365, 03-1366, 03-1367, 03-1368]
12/23/03	CLERK'S ORDER filed [793101] granting non-party motion(s) to intervene filed by St. MI, St. TX, St. ID, St. ND, St. UT, St SD, St. AK, St KS, St. NE, St OH [788217-1], filed by Alli Auto Mftr, Nat Auto Dlrs Assn, Engine Mftr Assn, Trk Mfg Assn [788169-1] in 03-1361, filed by Util Air Regu Grp, filed by CO2 Litigation Grp [788583-1], filed by Alli Auto Mftr, Nat Auto Dlrs Assn, Engine Mftr Assn, Trk Mfg Assn [788518-1] in 03-1365.
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	03-1361, 03-1362, 03-1363, and 03-1364 Are Denied, and the Petitions for Review in Nos. 03-1365, 03-1366, 03-1367, and 03-1368 Are Dismissed for the Reasons in the Accompanying Opinion. Before Sentelle, Randolph, Tatel.
7/15/05	OPINION filed [906086] (15 pgs) for the Court by Judge Randolph, DISSENTING OPINION (5 pgs) filed by Judge Sentelle, DISSENTING OPINION (38 pgs) filed by Judge [Tatel].
8/29/05	PETITION FOR REHEARING [916280-1] and PETITION, for rehearing en banc [916280-2], 20 copies) filed by Petitioner Cm MA in 03-1361, Petitioner St ME in 03-1361, Petitioner St NM in 03-1361, Petitioner St RI in 03-1361, Petitioner St WA in 03-1361, Respondent EPA in 03-1361.
12/2/05	PER CURIAM ORDER, In Banc, filed [955017] denying suggestion for rehearing en banc [916280-2] filed by Cm MA, et al. in 03-1361. Before Judges Sentelle, Henderson,* Randolph, Rogers,** Tatel,** Garland* Brown, Griffith.** [PUBLISHED IN OPINION FORMAT] [Entry Date: 12/2/05] [03-1361, 03-1362, 03-1363, 03-1364, 03-1365, 03-1366, 03-1367, 03-1368] (*Circuit Judges Henderson and Garland did not participate in this matter. **Circuit Judges Rogers, Tatel, and Griffith would grant the petition for rehearing en banc. A separate Statement by Circuit Judge Tatel, in which Circuit Judge Rogers joins, dissenting from the denial of rehearing en banc, is

attached.)

12/2/05	PER CURIAM ORDER filed [935024] denying petition rehearing [916280-1] filed by Cm MA, et al. (Mandate may issue on or after 12/12/05 in 03-1361, et al.) Before Judges Sentelle, Randolph, Tatel*. (Circuit Judge Tatel would grant the petition for rehearing) [Entry Date 12/2/05] [03-1361, 03-1362, 03-1363, 03-1364, 03-1365, 03-1366, 03-1367, 03-1368]

BEFORE THE ADMINISTRATOR OF THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

INTERNATIONAL CENTER FOR TECHNOLOGY ASSESSMENT, 310 D Street, N.E. Washington, DC 20002, *et al.*, *Petitioners*,	)	
vs.	)	Docket No. [A-2000-04]
HON. CAROL BROWNER, in her official capacity as, Administrator of the United States Environmental Protection Agency 401 M Street, S.W. Room W1200 Washington, DC 20460, *Defendant.*	)	

PETITION FOR RULEMAKING AND COLLATERAL RELIEF SEEKING THE REGULATION OF GREENHOUSE GAS EMISSIONS FROM NEW MOTOR VEHICLES UNDER § 202 OF THE CLEAN AIR ACT

Int'l. Ctr. For Tech Assm't
Legal Petition to EPA - October 20, 1999
[footer deleted from subsequent pages]

Pursuant to the Right to Petition Government Clause contained in the First Amendment of the United States

Constitution,[1] the Administrative Procedure Act,[2] the Clean Air Act,[3] and the Environmental Protection Agency ("EPA") implementing regulations, petitioners file this Petition for Rulemaking and Collateral Relief with the Administrator and respectfully requests her to undertake the following mandatory duties:

(1). Regulate the emissions of carbon dioxide (CO_2) from new motor vehicles and new motor vehicle engines under § 202(a)(1) of the Clean Air Act;

(2). Regulate the emissions of methane (CH_4) from new motor vehicles and new motor vehicle engines under § 202(a)(1) of the Clean Air Act;

(3). Regulate the emissions of nitrous oxide (N_20) from new motor vehicles and new motor vehicle engines under § 202(a)(1) of the Clean Air Act;

(4). Regulate the emissions of hydrofluorocarbons (HFCs) from new motor vehicles and new

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[1] "Congress shall make no law . . . abridging . . . the right of the people . . . to petition Government for a redress of grievances." U.S. Const., amend. I. The right to petition for redress of grievances is among the most precious of the liberties safeguarded by the Bill of Rights. United Mine Workers of America, Dist. 12 v. Illinois State Bar Association, 389 U.S. 217, 222, 88 S. Ct. 353, 356, 19 L. Ed. 2d 426 (1967). It shares the "preferred place" accorded in our system of government to the First Amendment freedoms, and has a sanctity and a sanction not permitting dubious intrusions. Thomas v. Collins, 323 U.S. 516, 530, 65 S. Ct. 315, 322, 89 L. Ed. 430 (1945). "Any attempt to restrict those First Amendment liberties must be justified by clear public interest, threatened not doubtful or remotely, but by clear and present danger." Id. The Supreme Court has recognized that the right to petition is logically implicit in, and fundamental to, the very idea of a republican form of government. United States v. Cruikshank, 92 U.S. (2 Otto) 542, 552, 23 L. Ed. 588 (1875).

[2] 5 U.S.C. § 553(e) (1994).

[3] 42 U.S.C. § 7401, *et seq.* (1994).

motor vehicle engines under § 202(a)(1) of the Clean Air Act;

PETITIONERS

Petitioner *International Center for Technology Assessment* (CTA) is located at 310 D Street, N.E., Washington, DC 20002. Formed in 1994, CTA seeks to assist the public and policy makers in better understanding how technology affects society. CTA is a non-profit organization devoted to analyzing the economic, environmental, ethical, political and social impacts that can result from the application of technology or technological systems.

Petitioner *Alliance for Sustainable Communities* is located at 2041 Shore Drive, Edgewater, MD 21037. The Alliance was formed five years ago in order to bring together representatives of government at all levels, citizens and innovators to develop projects which express the primary relationship between people and the earth.

Petitioner *Applied Power Technologies, Inc.* (APT) is located at 357 Imperial Blvd., Cape Canaveral, FL 32920-4219. APT is a research & development concern bringing new energy conversion systems to the air-conditioning industry on behalf of the natural gas industry. APT will advent the deregulation and decentralization of power production by producing nearly pollution-free air-conditioning, refrigeration and related appliances which will convert clean natural gas into electric offsetting heat energy on-site of actual end usage.

Petitioner *Bio Fuels America* is located at 28 Lorin Dee Drive, Westerlo, NY 12193. Bio Fuels America is a not for profit, self funded, advocacy group that promotes renewable energies such as wind, sun and biomass.

Petitioner *The California Solar Energy Industries Association* (CAL SEIA) is located at 23120 Alicia Parkway, Ste. 107, Mission Viejo, CA 92692.CAL SEIA is a solar industry trade association with 70 member companies who do business in California. CAL SEIA's members include manufacturers of both solar thermal and photovoltaic technologies, as well as distributors, contractors, architects, engineers and utilities.

Petitioner *Clements Environmental Corporation* is located at 3607 Seneca Avenue, Los Angeles, CA 90039. Clements Environmental Corp. is a small environmental engineering firm specializing in the conversion of Municpal Solid Waste and other waste organics to biofuels and biochemicals.

Petitioner *Environmental Advocates* is located at 353 Hamilton Street, Albany, NY 12210. Environmental Advocates serves the people of New York as an effective and aggressive watchdog and advocate on virtually every important state environmental issue. Through advocacy, coalition building, citizen education and policy development, we work to safeguard public health and preserve our unique natural heritage. With thousands of individual supporters and over 130 organizational members, Environmental Advocates is truly the voice of New York's environmental community.

Petitioner *Environmental and Energy Study Institute (EESI)* is located at 122 C St. NW, Suite 700, Washington, D.C. 20001. EESI is a non-profit organization founded in 1982 by a bipartisan group of Members of Congress. EESI promotes public policy that sustains people, the environment and our natural resources. EESI's wide-ranging audience includes Congress and other national policymakers, as well as state and local officials, industry leaders, the public interest community, the media, and the general public. EESI draws together timely

information, innovative public policy proposals, policymakers, and stakeholders to seek solutions to environmental and energy problems.

Petitioner *Friends of the Earth* is located at 1025 Vermont Ave., NW, Suite 300, Washington, DC 20005 Friends of the Earth is a national environmental organization dedicated to preserving the health and diversity of the planet for future generations. As the largest international environmental network in the world with affiliates in 63 countries, Friends of the Earth empowers citizens to have an influential voice in decisions affecting their environment.

Petitioner *Full Circle Energy Project, Inc.* is located at 6 Brooklawn Road, Wilbraham, MA 01095-2002. Full Circle Energy Project, Inc. is a non-profit organization founded to enable environmentally sensible and sustainable energy resources to supply at least 50% of the total energy used in the United States. Its primary focus is on reducing the amount of fossil fuels used by the transportation sector.

Petitioner *The Green Party of Rhode Island* is located in Providence, RI. The Green Party of RI is a part of the international Green Party movement. In Rhode Island it has run candidates for a variety of offices, always focusing on environmental issues as well as justice, non violence, and democracy issues.

Petitioner *Greenpeace USA* is located at 1436 U Street, NW, Washington, DC 20009. Greenpeace is one of the world's major environmental organizations with offices in 33 countries, including the United States of America, and over 3 million donating supporters worldwide. Greenpeace is a non-profit organization devoted to the protection of the environment with an emphasis on global environmental problems such as climate change and protection of the stratospheric ozone layer,

prevention of nuclear, chemical and biological pollution, and defense of biodiversity.

Petitioner *Network for Environmental and Economic Responsibility of the United Church of Christ*, Washington Office, 1820 Sanford Road, Wheaton, MD 20902-4008. The Network for Environmental and Economic Responsibility (NEER) is a grassroots, volunteer movement committed to mobilizing UCC persons, networks and resources for a holistic ministry of learning, reflection, and action cognizant of the earth and its creatures. Network members believe that all living things on our planet are interdependent in a vast web of life.

Petitioner *New Jersey Environmental Watch* is located c/o St. John's Church, 61 Broad Street, Elizabeth, NJ 07201. New Jersey Environmental Watch is a church based organization in New Jersey that seeks better air in their area and elsewhere. Recently, it recorded 40 percent of our Sunday School children had been hospitalized for asthma. It is also in cancer alley and have greatly elevated cancer rates. The 14-lane New Jersey Turnpike passes through Elizabeth, NJ the bottom 40 percent of the Newark Airport is located there as well, and Elizabeth is immediately downwind of the huge Bayway Tosco refinery in Linden.

Petitioner *New Mexico Solar Energy Association* (NMSEA) is located at P.O. Box 8507 Santa Fe, NM 87505. NMSEA is an all volunteer organization working to further solar and related arts, sciences, and technologies with concern for the ecologic, social and economic fabric of the region. It serves to inform public, institutional and government bodies and seeks to raise the level of public awareness of these purposes.

Petitioner *Oregon Environmental Council* (OEC) is located at 520 SW 6th Avenue, Suite 940, Portland, OR 97204-1535. OEC, founded in 1968, is Oregon's oldest statewide environmental group. OEC works to restore and protect Oregon's water and air by creating and promoting environmental policies.

Petitioner *Public Citizen* is located at 215 Pennsylvania Ave., SE, Washington, DC 20003. Public Citizen, founded by Ralph Nader in 1971, is a non-profit research, lobbying, and litigation organization based in Washington, DC. Public Citizen advocates for consumer protection and for government and corporate accountability, and is supported by over 150,000 members throughout the United States.

Petitioner *Solar Energy Industries Association (SEIA)* is located at 1111 North 19th Street, Suite 260, Arlington, VA 22209. The Solar Energy industries Association (SEIA), founded in 1974, is the U.S. industry organization composed of over 150 solar-electric and solar thermal manufacturers, component suppliers, national distibutors and project developers, and an additional 400 companies in the SEIA--affiliated state and regional chapters covering 35 states.

Petitioner *The SUN DAY Campaign* is located at 315 Circle Avenue, Suite #2, Takoma Park, MD 20912-4836. The SUN DAY Campaign is a non-profit network of 850+ businesses and organizations founded in 1991 to promote increased use of renewable energy and energy efficient technologies. Areas of work include research on sustainable energy technologies, electric utility restructuring, climate change, and the federal energy budget. Projects include publication of a weekly newsletter, an annual series of directories of sustainable energy organizations, and other studies.

STATEMENT OF LAW

Clean Air Act, Section 302(g), 42 U.S.C. § 7602(g):

> The term "air pollutant" means any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which is emitted into or otherwise enters ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator has identified such precursor or precursors for the particular purpose for which the term "air pollutant" is used.

Clean Air Act, Section 202(a)(1), 42 U.S.C. § 7521(a)(1)*:*

> The Administrator shall by regulation prescribe (and from time to time revise) in accordance with the provisions of this section, standards applicable to the emission of any air pollutant from any class or classes of new motor vehicle or new motor vehicle engine, which in his judgment cause, or contribute to, air pollution which may be reasonably anticipated to endanger public health or welfare. Such standards shall be applicable to such vehicles and engines for the useful life . . . whether such vehicle or engines are designed as complete systems or incorporate to devices to prevent the control of such pollution.

U.S. Constitution, amendment I

Administrative Procedure Act, 5 U.S.C. § 551, *et seq.*

All other applicable statutes and regulations.

BRIEF STATEMENT OF FACT

The Earth's temperature is increasing. Scientists from the National Oceanic and Atmospheric Administration ("NOAA"), the U.S. Regional Climate Centers, and the World Meteorological Organization all agree that 1998 was the warmest year on record.[4] The temperature increases recorded in 1998 represent a steady trend over the past twenty years of record breaking global surface temperatures.[5] The United Nations Intergovernmental Panel on Climate Change ("IPCC"), an authoritative body of more than two thousand of the world's leading climate change scientists, stated that the emission of anthropogenic greenhouse gases, including carbon dioxide ("CO_2"), methane ("CH_4"), nitrous oxide ("N_2O"), and hydrofluorocarbons ("HFCs") [hereinafter referred to collectively as "greenhouse gases"], are significantly accelerating this current warming trend.[6] Human activities are increasing the concentration of heat trapping greenhouse gases in the atmosphere and the effect is called global warming. Due to these high fossil fuel emission levels, the IPCC warned that:

> carbon dioxide remains the most important contributor to anthropogenic forcing of climate change; projections of future global mean temperature change and sea level rise confirm the potential for human activities to alter

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[4] National Oceanic and Atmospheric Administration (January 12, 1999), http://www.ncdc.noaa.gov/ol/climate/research/1998/ann/ann98.html.

[5] Id.

[6] United Nations Environmental Programme (UNEP)/World Meteorological Organization (WMO), Climate Change 1995: The Science of Climate Change. Technical Summary of Working Group I of the Intergovernmental Panel on Climate Change [hereinafter Climate Change 1995, Pet. Ex. 1].

Earth's climate to extent unprecedented in human history.[7]

Approximately 90% of U.S. greenhouse gas emissions from anthropogenic sources occurs because of the combustion of fossil fuel.[8] U.S. mobile sources are responsible for a significant amount of greenhouse gas emissions. In fact, in the United States, the fossil fuel CO_2 emissions from cars and light trucks are higher than the total nationwide CO_2 emissions from all but three other countries (China, Russia, and Japan).[9]

This anthropogenic forcing of climate change will affect not only the environment, but will also significantly impact human health. At a conference on Human Health and Global Climate Change, cosponsored by the National Science and Technology Council and the Institute of Medicine, Vice President Al Gore outlined the potential health risks caused by global warming and stated that measures must be taken to safeguard the American people.[10] Additionally, the conference participants stated that the lack of complete data on this issue should not be used as an excuse for inaction.[11] Instead, the participants urged governments to apply the precautionary principle to its decision making concerning global warming.[12]

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[7] Id. at 3.

[8] U.S. Department of Energy, TECHNOLOGY OPPORTUNITIES TO REDUCE U.S. GREENHOUSE GAS EMISSIONS, xiii (Oct. 1997).

[9] John DeCicco and Martin Thomas, GREEN GUIDE TO CARS AND TRUCKS, 2 (1999).

[10] The Conference on Human Health and Global Climate Change, September 11, 1995, at 4 [hereinafter Conference on Human Health and Global Climate Change, Pet. Ex. 2].

[11] Id. at 1.

[12] Id.; (The "precautionary principle" urges action to regulate activities which may be harmful to the environment *even* if conclusive scientific

(continued...)

Embodied in this request is an understanding that the tremendous potential risks to public health posed by global warming dictate that governments must act with precaution and take all prudent steps necessary to reduce the emission of anthropogenic greenhouse gases.

Within the context of United States governmental decision making, the precautionary principle is embraced by the Clean Air Act ("CAA"), a statute allowing for the implementation of a regulatory framework mandating the reduction of greenhouse gases. Under the CAA, the Administrator is permitted to make a precautionary decision to regulate pollutants in order to protect public health and welfare.[13] In addition to the precautionary nature of the CAA, the Administrator has a mandatory duty to regulate greenhouse gas emissions from new motor vehicles under § 202(a)(1) of the CAA. Petitioners urge the Administrator to reduce the effects of global warming by regulating the emission of greenhouse gases from new motor vehicles.

(...continued)
evidence of their harmfulness is not yet available. At its most profound, the precautionary principle dictates the institutionalization of precaution, which entails the shifting of the burden of proof from those opposing environmental degradation to those engaged in the challenged activity. *See e.g.*, Philippe Sands, ed., GREENING INTERNATIONAL LAW (New Press/1994) at 118.)

[13] See H.R. Rep. No. 294, 95th Cong., 1st Sess. 49 (1977).

ARGUMENT

I. GREENHOUSE GAS EMISSIONS FROM NEW MOTOR VEHICLES MUST BE REGULATED UNDER § 202(a)(1) OF THE CLEAN AIR ACT.

Under § 202(a)(1) of the Clean Air Act, 42 U.S.C. § 7521(a)(1), the Administrator is directed to prescribe standards for the emission of greenhouse gases from new motor vehicles[14] if she has determined that: (1) the emission of a greenhouse gas is an "air pollutant" and is emitted from new motor vehicles; *and* (2) the emission causes or contributes to air pollution which may reasonably be anticipated to endanger public health *or* welfare. For the reasons contained herein, the Administrator has made such determinations for greenhouse gases, including CO_2, CH_4, N_2O, and HFCs, and petitioners request the Administrator to undertake her mandatory duty to regulate these as directed by § 202(a)(1) of the CAA.

A. Greenhouse Gases Meet The Definition Of "Air Pollutant" Under The Clean Air Act And Are Emitted From New Motor Vehicles.

Pursuant to § 302(g), 42 U.S.C. § 7602(g), of the CAA, an "air pollutant" is defined as:

> any air pollutant agent or combination of such agents including any physical, chemical, biological, radioactive (including source material, special nuclear material, and byproduct material) substance or matter which

[14] Section 202 applies to new motor vehicles and new motor vehicle engines. Hereinafter, petitioners' reference to "new motor vehicles" also applies to "new motor vehicle engines."

> is emitted into or otherwise enters ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent the Administrator had identified such precursors or precursors for the particular purpose for which the term "air pollutant" is used.

Courts have interpreted this definition in an extremely broad manner.[15] The greenhouse gas emissions that the petitioners request the Administrator to regulate under § 202(a)(1) meet the CAA's broad statutory definition of "air pollutant" and are emitted from new motor vehicles.

(1) Emission of Carbon Dioxide

Carbon dioxide (CO_2) meets the § 302(g) definition. Over the last several decades, levels of CO_2 emissions have sharply risen causing the natural equilibrium of emissions and absorption to fall out of balance. Although CO_2 is a naturally occurring gas that is produced by living organisms and absorbed by oceans and trees, the extensive burning of fossil fuels has dramatically increased CO_2 levels and disrupted this natural equilibrium.[16] In fact, the U.S. Climate Action Report's "Greenhouse Inventory," submitted under the United Nations Framework Convention on Climate Change, states that CO_2 is considered the most significant greenhouse gas in the U.S. because it encompasses eighty-five percent of the total U.S. greenhouse gas emissions.[17] Due to the global warming dangers connected with the high emissions of CO_2, this greenhouse gas satisfies the definition of "air pollutant" under the CAA.

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[15] Alabama Power Co., v. Costle, 636 F.2d 323, 353 (D.C. Cir. 1979).

[16] Greenhouse Gas Inventory, U.S. Climate Action Report 7 (1997) [hereinafter U.S. Climate Action Report, Ex. 3].

[17] Id.

Additionally, mobile sources emit significant amounts of CO_2. The transportation sector contributes over 30% of U.S. greenhouse gas CO_2 emissions from fossil fuel combustion.[18] Almost two-thirds of the emissions come from automobiles and the remaining emissions come from trucks and aircraft.[19] The greenhouse gas emissions from transportation sources are predicted to grow faster than any other emission source.[20]

Finally, the agency has already made a legal determination that CO_2 meets the definition contained in § 302(g). In an April 10, 1998, memorandum to the Administrator, EPA General Counsel Jonathan Z. Cannon found that the broad definition of § 302(g) "states that 'air pollutant' includes any physical, chemical biological, or radioactive substance or matter that is emitted into or otherwise enters ambient air. SO_2, NO_x, CO_2 and mercury from electric power generation are each a "physical [and] chemical . . . substance which is emitted into . . . the ambient air," and hence, each is an air pollutant within the meaning of the Clean Air Act."[21] The memorandum further notes that Congress explicitly recognized CO_2 emissions as an "air pollutant" under § 103(g) of the Clean Air Act.[22] Recently, EPA again made this legal determination during hearings before Congress.[23]

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[18] Department of Energy, Reducing Greenhouse Transportation Sector Emissions, http://www.esd.ornl.gov/bfdp/biowin/reducing.html.

[19] U.S. Climate Action Report, Ex. 3 at. 8.

[20] Id.

[21] Johnathan Z. Cannon, Memorandum to Carol M. Browner, Adminsitrator, "EPA's Authority to Regulate Pollutants Emitted by Electric Power Generation Sources." (April 10, 1998).

[22] Id.

[23] Testimony of Gary S. Guzy, General Counsel, U.S. E.P.A., before a Joint Heaing of the Subcommitttee on National Economic Growth, Natural Resurces and Regulatory Affairs of the Committee on Government Reform (continued...)

(2) Emission of Methane

Methane (CH_4) should also be considered an "air pollutant" under § 302(g) of the CAA because of its contribution to global warming. The U.S. Climate Action Report indicates that CH_4 "is estimated to be twenty-one times more effective at trapping heat in the atmosphere than CO_2 over a 100-year time horizon."[24] During the past two centuries, CH_4 concentrations have more than doubled due to human activities.[25] Because CH_4 is a potent greenhouse gas, it satisfies the definition of "air pollutant" under the CAA. Furthermore, motor vehicles fueled by gasoline emit CH_4. The EPA's most recent inventory of greenhouse gas emissions indicates that in 1997 gasoline powered cars, trucks, and heavy-duty vehicles emitted 1.2 MMTCE of CH_4.[26]

(3) Emission of Nitrous Oxide

Nitrous oxide (N_2O) is a greenhouse gas that is produced naturally by biological sources in soil and water. However, over the past two centuries, N_2O levels have increased by eight percent due to human activities.[27] The U.S. Climate Action Report explains that "[w]hile N_2O emissions [sic] are much lower than CO_2 emissions, N_2O is approximately 310 times more powerful than CO_2 at trapping heat in the

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[23] (...continued)
and the Subcommittee on Energy and Environment of the Committee on Science, United States House of Representatives. (October 6, 1999).

[24] Id. at 10.

[25] Id.

[26] EPA, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1997, 36 (Mar. 1999).

[27] U.S. Climate Action Report, Ex. 3 at 13.

atmosphere over a 100-year horizon."[28] As a result, N_2O meets the CAA definition of "air pollutant."

This greenhouse gas is also emitted from motor vehicles during fossil fuel combustion.[29] Due to the installation of catalytic converters, a device designed to reduce air pollution, the volume of N_2O emitted from motor vehicles has risen.[30]

(4) Emission of Hydrofluorocarbons

Hydrofluorocarbons (HFCs) is a powerful greenhouse gas that meets the definition of "air pollutant" under the CAA. HFCs were introduced as alternatives to chlorofluorocarbons, which are ozone depleting substance.[31] Although these gases do not directly destroy ozone, they do contribute to global warming.[32] HFCs impact the ambient air by contributing to global warming as much as 10,000 times that of CO_2.[33] The emissions of HFCs from motor vehicles have increased since 1993 due to the use of HFC-134a in mobile air conditioners.[34]

As discussed above, the four greenhouse gases subject to this petition have been determined to accelerate global warming. Additionally, the agency has already made the determination that CO_2 is an "air pollutant"as defined under the CAA. Accordingly, similar determinations that the emissions of CH_4, N_2O, and HFCs from motor vehicles also meet the definition of "air pollutant" under § 302(g) of the CAA follow.

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[28] Id.

[29] Id.

[30] Id.

[31] MSNBC, Greenhouse gases under review, http://www.msnbc.com/news/127171.asp.

[32] Id.

[33] Id.

[34] U.S. Climate Action Report, Ex. 3 at 16.

B. *The Emission Of Greenhouse Gases Contributes To Pollution Which Is Reasonably Anticipated To Endanger Public Health And Welfare.*

Pursuant to the requirements of §202(a)(1), greenhouse gas emissions from new motor vehicles must also be regulated under the CAA because of their endangerment to public health or welfare. When determining what constitutes an endangerment to public health and welfare, the CAA does not require proof of actual harm. Instead, the Administrator is permitted to make a precautionary decision to regulate a pollutant if it "may reasonably be anticipated" to endanger public health or welfare.[35] This requirement is confirmed by the CAA's legislative history. The House Report accompanying the 1977 Amendments states that one of the CAA's purposes is "[t]o emphasize the preventive or precautionary nature of the act, i.e., to assure that regulatory action can effectively prevent harm before it occurs; to emphasize the predominant value of protection of public health."[36] As enumerated below, the EPA and other federal agencies have already made numerous findings that greenhouse gas emissions from new motor vehicles are air pollutants reasonably anticipated to endanger public health and welfare. Therefore, the Administrator has the statutory obligation to regulate the emissions of air pollutants from new motor vehicles under § 202(a)(1) in order to prevent future harm.

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[35] Engine Mfr. Ass'n v. EPA, 88 F.3d 1075, 1099 (D.C. Cir. 1996); *See also*, Lead Industries Assoc., 647 F.2d at 1156 (explaining that the 1977 CAA amendments made the threshold decision to regulate air pollutants precautionary in nature.).

[36] H.R. Rep. No. 294, 95th Cong., 1st Sess. 49 (1977)(stating that Congress used the phrase "may reasonably be anticipated to endanger public health or welfare" to emphasize the precautionary nature of the CAA. This phrase is present in sections 108, 111, 112, 202, 211, and 231.)

(*1*). *The Emission of Greenhouse Gases Will Endanger Public Health.*

The IPCC reports that greenhouse gas emissions are significantly accelerating current warming trends and estimates that by the year 2100, the Earth's temperature will have changed by two degrees Celsius.[37] As a result of increased temperatures, the EPA reports that certain infectious diseases may become more prevalent in geographic areas that were once free from the threat of such diseases.[38] In particular, global warming may increase vector-born diseases such as malaria, dengue fever, encephalitis, and hantavirus along with increasing water-born diseases such as cholera, toxic algae, and cryptosporidiosis. Changing climate conditions will also increase the likelihood of direct effects on human health, including heat stress, skin cancer, cataracts, and immune suppression.

(a). Global Warming Increases the Threat of Infectious Diseases.

1. Increases in Vector-borne Diseases.

Infectious diseases kill over seventeen million people each year.[39] Vector-borne diseases, usually caused by a microbial, insect or small mammal vector, cause a large portion of those fatalities.[40] The spread of vector-borne diseases is a serious concern because disease vectors are sensitive to climate

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[37] Jonathan A. Patz, Public Health Effects of Climate Change Synthesis of the IPCC Findings, 2 (1996) [hereinafter IPCC, Ex. 4].

[38] EPA, Global Warming, http://www.epa.gov/globalwarming/impacts/health/index.html.

[39] IPCC, Ex. 4 at 7

[40] Id.

variations.[41]

Malaria is the most prevalent vector-born disease. Although this disease generally occurs in the tropics and subtropics, the U.S. is not immune from this disease as indicated by the latest Center for Disease Control ("CDC") report. [42] The CDC reports a 15% increase in cases of malaria in the U.S from 1994 thru 1995.[43] Unseasonably warm weather increases the transmission of malaria. Consequently, the IPCC reports that more than one million additional fatalities from malaria is estimated to occur by the middle of the next century due to global warming.[44]

Dengue and Dengue hemorrhagic fever is a painful flu-like illness transmitted by a mosquito bite that is increasing not only in the tropics, but also in the Americas.[45] Warmer temperatures contribute to the spreading of this disease to higher latitudes and altitudes.[46] In fact, dengue was "observed in Mexico at an unprecedented altitude of 1,700 meters during an unseasonably warm summer in 1988."[47] The IPCC report states that, when temperatures increase, more infectious mosquitos hatch resulting in more people being bitten.[48]

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[41] Id. at Table 18-3 (data on the diseases that are likely to be affected by climate change).

[42] Id. at 7.

[43] Malaria Surveillance – United States, 1995, http://www.cdc.gov/epo/mmwr/preview/mmwrhtml/00056518.htm (citing 1,167 cases of malaria in the U.S. in 1995).

[44] IPCC, Ex. 4 at 8.

[45] Id.

[46] Id.

[47] Id.

[48] Id.

Arboviral encephalitis is another vector-borne disease that is highly correlated to warm temperatures. Outbreaks of this disease have occurred in the U.S. after several days when the temperature exceeded eighty-five degrees Fahrenheit.[49] Heavy rainfall during winter months and drought during summer months is another predictor for this disease. The effect of global climate change predicted for the U.S. is warm, wet winters and hot, dry summers. These conditions foster an environment for the spread of arboviral encephalitis.[50]

Hantavirus is a deadly infectious disease caused by infected deer mice or cotton rats.[51] The CDC reported an outbreak of this illness in the southwest U.S in 1993.[52] This epidemic occurred when six years of drought preceded heavy spring rains.[53] This ecological change resulted in an increase of the rodent population ten times its normal size and, consequently, caused the outbreak of hantavirus.[54] Reports of this disease have occurred in the western U.S. and in a few eastern states.[55]

2. Increases in Water-borne Diseases.

During the past century, sea surface temperatures have

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[49] Jonathan A. Patz and Paul R. Epstein, et al., Global Climate Change and Emerging Infectious Diseases, JAMA 219-220 (1996) [hereinafter JAMA].

[50] Id. at 220.

[51] Center for Disease Control, Hantavirus, Public Information area, http://www.cdc.gov/ncidod/diseases/hanta/hps/noframes/consumer.htm.

[52] JAMA, at 217.

[53] Id.

[54] Id.

[55] Center for Disease Control, HPS Case Information, http://www.cdc.gov/ncidod/diseases/hanta/hps/noframes/whatsnew.htm.

increased 0.7 degrees Celsius.[56] Increased temperature and nutrient water promotes the growth of toxic algae.[57] Toxic algae is dangerous because it causes shell-fish poisoning which may harm humans, sea mammals, and sea birds.[58]

Increased algae growth can also stimulate the incidence of cholera. Zooplankton feeds on algae and can serve as a reservoir for Vibrio cholera.[59] Increased algae blooms may increase the proliferation of a cholera epidemic. In Latin America, large coastal algae blooms are suspected to have perpetuated a cholera epidemic.[60] The IPCC reports that cholera may increase in the U.S. as sea temperatures increase.[61]

The most widespread waterborne disease in the U.S. is cryptosporidiosis.[62] This disease occurs when floods, heavy rains, and snow melts cause run-off on agricultural dairy farms contaminating the water.[63] For example, in 1993, Milwaukee reported 403,000 cases of this disease after experiencing unusually heavy spring rains and melting snow.[64] Rising sea levels will also affect the spread of this disease because saline

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[56] IPCC, Ex. 4 at 8.

[57] JAMA at 220 (nutrient waters develop from fertilizer runoff and sewage releases).

[58] Id. and IPCC, Ex. 4 at 12 (explaining that a species of toxic algae that was previously confined to the Gulf of Mexico traveled north after "a parcel of warm gulf stream water" rose up the east coast and the result was human shellfish poisonings and substantial fishkills).

[59] IPCC, Ex. 4 at 8.

[60] Id.

[61] Id at 12.

[62] Id.

[63] Id.

[64] IPCC, Ex. 4 at 12.

water extends the viability of this disease.[65]

Thus, significant research has shown that climate change affects the spread of numerous and life-threatening vector-borne and water-borne diseases. To protect public health by reducing the threat and spread of these diseases, EPA must immediately regulate the emissions of greenhouse gases from new motor vehicles under § 202(a)(1).

(b). Global Warming Will Have Direct Effects on Human Health.

1. Increases in Heat Stress.

The EPA reports that "the most direct effect of climate change would be the impacts of hotter temperatures."[66] Hotter temperatures affect the young, the elderly, and people with heart problems and causes increased cases of heat exhaustion, respiratory problems, and even death.[67]

The IPCC reports that the U.S. is expected to "warm disproportionately more than tropical and subtropical zones."[68] The effects from this temperature increase can be determined by reviewing data from past heat waves. The IPCC explains that data taken from Philadelphia during 1973 to 1988 shows that there is a relationship between temperature, humidity, and

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[65] Id.

[66] EPA, global warming, http://www.epa.gov/globalwarming/impacts/health/index.html.

[67] Id. (explaining that higher temperatures increase ozone at ground level which can cause respiratory problems) and see Conference on Human Health and Global Climate Change, Ex. 2 at 9 (reporting that 726 people died in 1995 during a heatwave in Chicago).

[68] IPCC, Ex. 4 at 11.

mortality.[69] Based on data taken from several North American cities, the IPCC predicts that "the annual number of heat-related deaths would approximately double by 2020 and would increase several-fold by 2050."[70]

2. Increases in Skin Cancer, Cataracts, and Immune Suppression.

Greenhouse gases prevent heat from entering the stratosphere. As a result, ice crystal formations increase in the upper stratosphere destroying the ozone layer.[71] Ozone destruction increases the amount of ultraviolet-B radiation entering the earth's surface, which impacts public health by directly contributing to skin cancer, cataracts, and immune suppression.

A CDC report indicates that most of the top ten cancers declined between 1990 and 1995 except for incidence of skin cancer.[72] Skin cancer is the most common cancer in the U.S and the incidence of melanoma has doubled since 1973.[73] The U.S. National Cancer Institute explains that "[n]early all skin cancers occur in fair-skinned individuals who have been exposed to the sun, x-rays, or ultraviolet light for prolonged periods."[74] The participants at the Conference on Human Health and Global Climate Change predict that skin cancer will

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[69] Id.

[70] Id.

[71] Id. at 10.

[72] Center for Disease Control, 1998 News Release, http://www.cdc.gov/nchswww/releases/98news/98news/cancer.htm

[73] American Cancer Society, Skin Cancer - Melanoma, http://www3.cancer.org/cancerinfo/main_cont.asp?st=wi&ct=50.

[74] Id.

increase two percent for every one percent decrease in stratospheric ozone.[75]

Ultraviolet B-radiation is also associated with the development of cataracts. Half of the blindness in the world is attributed to cataracts.[76] IPCC predicts that a ten percent loss of stratospheric ozone will result in approximately 1.7 million additional cases of cataracts annually.[77]

Immune suppression is also a direct effect from global warming. The IPCC report states that "UV light has been shown to cause immune suppression in both animal and human studies."[78] Immunosuppression decreases the strength of the human immune system.

Therefore, the human health effects of climate change will also be exacerbated by increasing humans' susceptibility to heat stress, skin cancer, and cataracts. These direct threats to public health immediately mandate the EPA to regulate the emissions of greenhouse gases from new motor vehicles under § 202(a)(1).

(2). The Emission of Greenhouse Gases Will Endanger Public Welfare.

In addition to endangering public health, the emission of greenhouses gases will also harm the public welfare. Under the CAA, public "welfare" is defined as:

> All language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, manmade materials,

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[75] Conference on Human Health and Global Climate Change, Ex. 2 at 12.

[76] IPCC, Ex. 4 at 10.

[77] Id.

[78] Id.

> animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants.[79]

There have been numerous EPA findings that greenhouse gas emissions will endanger "public welfare" as defined by this section of the CAA. In fact, the EPA has researched the potential environmental impacts from climate change and reports that global warming will significantly harm the environment.

(a). Global Warming Will Harm Environmental Welfare.

The emission of greenhouse gases and the consequential effects of global warming will severely harm the quality of the United States environment. Global warming will harm, *inter alia*, water resources, rangelands, forests, non-tidal wetlands, fisheries and birds.

1. Harm to Water Resources.

Evaporation and precipitation is expected to increase due to global warming. The EPA predicts that "[l]ower river flows and lower lake levels could impair navigation, hydroelectric power generation, and water quality, and reduce the supplies of water available for agriculture, residential, and

[79] 42 U.S.C. § 7602(h)(emphasis added); *See*, Engine Mfr. Ass'n, 88 F.3d at 1099 (Reaffirming the broad authority of the Administrator to make this determination).

industrial uses."[80] Furthermore, increased rainfall will likely result in flooding.[81]

2. Harm to Rangelands and Forests.

Global warming will likely harm grazing activities on both federal and private lands. The EPA predicts the decrease in the availability of water in these areas will harm the economic viability of grazing on rangelands.[82]

As temperatures increase, many North American forests will shift to the north.[83] The distance that trees will have to migrate will depend on how fast temperatures increase.[84] As temperatures increase, the soil will become drier, which will escalate the likelihood of forest fires.[85] Also, changes in pest populations will negatively affect the survival of forests.[86] Furthermore, the EPA reports that wildlife that depend on the habitat of nature reserves may be vulnerable because these areas may no longer be located in a climate suitable for the survival of many species.[87]

3. Harm to Non-tidal Wetlands.

Wetlands serve several purposes in protecting the environment. Wetlands provide a habitat for birds and fish and

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[80] EPA, Global Warming, http://www.epa.gov/globalwarming/impacts/water/index.html.

[81] Id.

[82] Id. at http://www.epa.gov/globalwarming/impacts/rangelands/index.html.

[83] Id. at http://www.epa.gov/globalwarming/impacts/forests/index.html.

[84] Id. (EPA recognizes the uncertainties that exist pertaining to changing climate and migrating forests).

[85] EPA, Global Warming, http://www.epa.gov/globalwarming/impacts/forests/index.html

[86] Id.

[87] Id.

also prevent run-off pollution from farms and other sources from entering rivers, lakes, and streams.[88] The EPA explains that the impact on wetlands from changing climate is uncertain because it depends on the amount of rainfall received by wetlands.[89] If wetland areas receive a decrease in rainfall, then the areas will become drier and significantly impair the wetland's function.[90] Dry land will force farmers to increase their use of irrigation which may further drain wetlands.[91] If the wetland areas receive an increase in rainfall, then flooding will occur.[92] Flooding will force people to move out of hazardous areas, which will benefit wetlands by allowing them to form. However, if people build dams in order to prevent flooding, which is likely, then the new structures, along with the decrease in flooding, will prevent wetlands from forming.[93]

4. Harm to Fisheries.

The EPA reports that climate change may impact inland fisheries, coastal fisheries, and ocean fisheries.[94] Increased water temperatures may be too warm for some species of fish.[95] Global warming might also harm many species of fish by changing the chemical composition of the water by decreasing the amount of oxygen and increasing the pollution and salinity

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[88] Id. at http://www.epa.gov/globalwarming/impacts/wetlands/index.html.

[89] Id.

[90] EPA, Global Warming, http://www.epa.gov/globalwarming/impacts/wetlands/index.html

[91] Id.

[92] Id.

[93] Id.

[94] EPA, Global Warming, http://www.epa.gov/globalwarming/impacts/fisheries/index.html.

[95] Id.

level.[96] Species that are dependent on wetlands for habitat and food would also be harmed if wetlands decrease.[97]

5. Harm to Bird Populations.

Global warming may impact birds by altering their life cycles. The National Audubon Society's bird data reveals that, during warming years, birds do not fly as far south and during the summer months, birds fly farther north.[98] The EPA indicates that this change in migration may be harmful to birds because the vegetation and insects they rely upon may take decades to synchronize with the birds' change in migration.[99]

Additionally, habitat loss due to global warming will impact many bird species. Rising sea levels will decrease estuarine beaches, which are habitats for the least tern, an endangered species.[100] The loss of wetlands and decreasing shellfish levels will also impact many species.[101]

As discussed above, EPA recognizes that the environmental welfare of the United States is impacted by the emission of greenhouse gases and the effects of global warming. The impacts include, *inter alia*, direct harm to our water resources, rangelands, forests, non-tidal wetlands, fisheries, and birds. Although there may be some uncertainties concerning the extent of these impacts from global warming, EPA must exercise precaution and mitigate these impacts by regulating the emissions of greenhouse gases from new motor

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[96] Id.

[97] Id.

[98] EPA, Global Warming, http://www.epa.gov/globalwarming/impacts/birds/index.html.

[99] Id.

[100] Id. at http://www.epa.gov/globalwarming/impacts/birds/index.html.

[101] Id.

vehicles under § 202(a)(1) of the CAA.

(b). Global Warming Will Harm Human Welfare.

The emission of greenhouse gases and resulting global warming will also severely harm the human welfare of the United States' population. Global warming will harm, *inter alia*, food production, nutritional health, weather patterns, sea-levels, water quality and quantity, and respiratory health.

1. Harm to Food Production and Nutritional Health.

Global warming is expected to change crop productivity.[102] Agricultural productivity may increase in some regions initially but longer-term adaptation is not as likely due to changes in plant physiology and the questionable availability of an adequate water supply.[103] Global warming may adversely affect agricultural production by reducing soil moisture through evapotranspiration and through extreme weather such as droughts, flooding, and tropical storms.[104] The IPCC report explains that one of the long term effects of global warming will be altered plant diseases and pest infestations.[105] As a result of these climate change affects on agriculture, an estimated 40-300 million additional people worldwide may be at risk from hunger.[106]

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[102] *See generally*, International Rice Research Institute and American Association for the Advancement of Science, "Climate and Food Security" 1989.

[103] Jonathan A. Patz, MD, MPH, "Public Health Effects of Climate Change: Synthesis of the IPCC Findings" Statement Prepared for a Roundtable Discussion of Senator Lieberman, 8 (June 11, 1996).

[104] IPCC, Ex. 4 at 8.

[105] Id.

[106] Id.

2. Weather Related Harm and Rising Sea Levels.

Extreme weather is predicted as a result of changing climate conditions.[107] More floods may occur due to the increased rain fall and more tropical cyclones are expected because of warmer sea surface temperatures.[108] Extreme weather will not only create physical harm and structural damage, but will also create breeding sites for insects and rodents carrying disease.[109] The IPCC anticipates that global warming will also encourage human dislocation from geographically vulnerable areas.[110] Droughts in West Africa have already forced mass migrations.[111]

Sea level rises are occurring rapidly in the U.S. The EPA estimates that "along the Gulf and Atlantic coasts, a one foot (30 cm) rise in sea level is likely by 2050 and could occur as soon as 2025. In the next century, a two foot rise is most likely, but a four foot rise is possible."[112] Developed areas will probably attempt to protect their property with bulkheads, dikes, and other structures, however, not all property will be protected and consequently, many people living in coastal areas will be forced to relocate.[113]

3. Harm to Water Quality and Quantity.

Rising sea levels will increase the salinity of surface and

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[107] IPCC, Ex. 4 at 9.

[108] Id.

[109] Id.

[110] Id.

[111] Id.

[112] EPA, Global Warming, http://www.epa.gov/globalwarming/impacts/coastal/index.html.

[113] Id.

ground water.[114] The EPA reports that New York, Philadelphia, and much of California's Central Valley will be susceptible to salty water during droughts if sea levels rise.[115] Climate effects will also increase flooding and water shortages.[116]

4. Harm From Air Pollution and Allergens.

The industrial processes that produce greenhouse gases also produce air pollutants.[117] In the U.S., air pollution causes 70,000 deaths and one million hospitalizations annually.[118] The participants at the Conference on Human Health and Global Climate Change predict that as pollution from greenhouse gases increases, "the health effects of air pollution on a global scale could be staggering."[119] Hotter temperatures and humidity may also lead to increased levels of plant pollen, which in turn would increase the cases of asthma and hay fever.[120]

In sum, significant scientific research and numerous EPA findings conclude that greenhouse gases will adversely affect human health and welfare in the United States by causing global warming. Based on these determinations, EPA must regulate the emissions of greenhouse gases from new motor vehicles under § 202(a)(1) of the CAA in order to mitigate the harmful impacts of global warming on both the environmental and human welfare.

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[114] Id. at http://www.epa.gov/globalwarming/impacts/coastal/index.html.

[115] Id. (some aquifers that are currently recharged by fresh water will become salty due to rising sea levels).

[116] IPCC, Ex. 4 at 9.

[117] Conference on Human Health and Global Climate Change, Ex. 2 at 13.

[118] Id.

[119] Id. at 14.

[120] Id.

II. IT IS TECHNICALLY FEASIBLE TO REDUCE GREENHOUSE GAS EMISSIONS FROM NEW MOTOR VEHICLES.

Agency action under § 202 will allow the EPA to implement a variety of regulatory standards to control greenhouse gas emissions. As contained in § 202, standards set under § 202 authority "shall be applicable to such vehicles and engines for the useful life . . . whether such vehicle or engines are designed as complete systems or incorporate devices to prevent the control of such pollution." Accordingly, this language allows the EPA latitude to utilize a number of options to address new motor vehicle greenhouse gas emissions so long as the options require the incorporation of complete systems or devices that reduce such emissions. Major automakers have already introduced car and truck designs that significantly reduce vehicle-related CO_2 formation, and many of these are already available to consumers and institutional purchasers at competitive prices. These vehicles generally rely on one of two strategies for reducing CO_2 emissions: increasing fuel economy and/or eliminating tailpipe emissions altogether. Standards assuring their rapid market adoption of these vehicles are necessary increases in new vehicle greenhouse gas emissions.

A. *Standards for Increased Corporate Average Fuel Economy.*[121]

According to the U.S. Department of Energy, "[T]he fuel economy of a vehicle is directly related to its emissions of carbon dioxide, the most important greenhouse gas." Furthermore, EPA added that:

> [E]ven though today's new vehicles cause much

[121] Petitioners assert that Section 202 provides the EPA with the authority to implement a corporate average fuel-economy based standard.

> less air pollution than in the past, their greenhouse gas emissions are as high as they were 15 years ago. A vehicle's greenhouse gas emissions are directly related to its fuel economy. Every gallon of gasoline that you use in a vehicle adds about 20 pounds of carbon dioxide to the atmosphere."[122]

The Corporate Average Fuel Economy (CAFE) standard for 1999 is 27.5 mpg, though the actual average fuel economy is somewhat lower than this because automakers are permitted to employ credits generated through an averaging, banking, and trading program. Also, light trucks, which make up a growing segment of passenger vehicle sales, are subject to less stringent fuel economy standards. Complete vehicle systems and incorporated devices that would significantly reduce new vehicle CO_2 emissions are currently in development or on the road. For example, the Union of Concerned Scientists has developed a blueprint for a sport utility vehicle utilizing devices that would emit 32 percent less CO_2 than comparable models now for sale.[123]

In addition, automakers have shown that the technology is available to support a more stringent CAFE standard. For the 1999 model year, a number of traditional, gasoline-powered cars achieve fuel economy ratings of at least 40 mpg on the highway. These include the Chevrolet Metro (1.0 liter/3 cylinder engine, 41 mpg city/47 mpg highway); Honda Civic HX (1.6/4, 35/43), Mitsubishi Mirage (1.5/4, 33/40), Saturn SL (1.9/4, 29/40), Suzuki Swift (1.3/4, 39/40), and Toyota Tercel

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[122] U.S. DOE, "Model Year 1999 Fuel Economy Guide," DOE/EE-0178, (Washington, DC: October 1998) at 2.

[123] David Welch, "Fuel-Efficient Sport-Utility Is Envisioned," Detroit *News*, July 16, 1999, at E15.

(1.5/4, 32/40).[124]

Even better fuel economy ratings are achievable. In 1991, the Congressional Office of Technology Assessment established a list of strategies for improving vehicle fuel economy. Many remain viable. These automotive technology and design improvements include: weight reduction, aerodynamic drag reduction, improved tires and lubricants, advanced engine friction reduction, two-stroke engines, and continuously variable transmissions that ensure optimal vehicle efficiency at all speeds.[125]

B. Increased Adoption of Hybrid and Non-Fossil Fuel Vehicles.

The setting of standards under § 202 will create the rapid market introduction of hybrid-electric and zero emission vehicles. By encouraging the development of this technology, the agency can effectively reduce greenhouse gas emissions from new vehicles.

Hybrid technologies utilize entirely new systems combining a gasoline-powered engine and a battery-powered electric motor. The energy used to charge the battery is typically generated by the gasoline engine. Toyota has sold nearly 30,000 of its hybrid-electric Prius in Japan since December 1997, and plans to release the model in the United States in 2000. In a recent 4,200-mile cross-continent trip, the Prius demonstrated a fuel economy of over 60 miles per

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[124] Id.

[125] U.S. Congress, Office of Technology Assessment, *Improving Automobile Fuel Economy: New Standards, New Approaches*, OTA-E-504 (Washington, DC: U.S. Government Printing Office, October 1991) at 4.

gallon.[126] Other automakers are also working on hybrid models. Honda plans to begin selling the Insight hybrid-electric vehicle in the United States in December of this year. The company claims that the car will get 84 miles per gallon of gasoline. General Motors, Ford, and DaimlerChrysler are also developing hybrid-electric vehicles, which they may release for public sale as early as 2001.[127] The setting of new § 202-based CAFE standards by the EPA would greatly enhance market penetration of these vehicles.

In addition, other new complete vehicle systems exist for reducing new vehicle greenhouse gas emissions. According to the California Air Resources Board, there are at least 16 zero-emission production vehicles now available to consumers in at least some states. These are electric vehicles (EVs) and include models of the Dodge Caravan, Ford Ranger pickup, General Motors S-10 pickup, and Plymouth Voyager. Recent technological advancements have dramatically increased the range of EVs. The General Motors EV-1 with a nickel metal hydride battery can travel up to 152 miles on a single charge, while the Toyota RAV 4 and Nissan Alta EVs also boast ranges exceeding 100 miles per charge.[128] EVs have no tailpipe emissions and carry the potential to reduce all automobile-related CO_2 emissions to near zero. The agency itself has found that, "[I]f power plants produce electricity using clean energy sources such as solar or hydro power, emissions are

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[126] "Environmental Adventurers First to Cross the U.S. in a Hybrid-Electric Car," PR Newswire, July 9, 1999.

[127] "Honda Unveils Fuel Efficient Car," Associated Press, July 6, 1999.

[128] California Air Resources Board, "Buyer's Guide to Cleaner Cars," updated March 8, 1999, <http://www.arb.ca.gov/msprog/ccbg/ccbg.htm>.

negligible."[129]

Additionally, fuel cell vehicles may soon offer another zero-emissions option. A fuel cell combines hydrogen and oxygen in a chemical reaction that produces electricity. The exhaust of a fuel cell running on pure hydrogen consists of water and hot air. Ford has developed a research vehicle known as the P2000 HFC, which runs on a fuel cell and emits no CO_2 precursors. The company plans to begin testing about 45 fuel cell cars and buses in California over the next several years.[130] Other companies developing automotive fuel cell technologies include Ballard Power Systems, DaimlerChrysler, and Toyota.

Unfortunately, the Agency's proposed Tier II standard has inadequately addressed the effects of greenhouse gas emissions, including CO_2 emissions, from new vehicles.[131] Given the agency's intention of using the Tier II process to develop a regulatory framework that addresses future automobile pollution, petitioners believe that the authority provided under § 202 requires the agency to incorporate standards into its Tier 2 proposal that would combat global warming by limiting the amount of CO_2 pollution created by light duty vehicles. For example, establishing a declining NO_x fleet average in the proposed Tier II regulation would, in part, achieve such a goal by requiring manufacturers to increase the number of vehicles certified to the zero emission vehicles standards of proposed Bin 1.

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[129] U.S. Environmental Protection Agency, "Electric Vehicles," Fact Sheet OMS-10, EPA 400-f-92-012, August 1994.

[130] Ford Motor Co., "Ford Motor Company Fuel Cell Program Delivers Zero-Emission Family Vehicle," company press release, July 22, 1999.

[131] *See generally*, The International Center for Technology Assessment's Comments on the U.S. Environmental Protection Agency's Tier 2 Proposal (Public Docket No. A-97-10), August 2, 1999.

Given the scope of authority granted to the Administrator under §202 and the existence of the requisite technologies, the Administrator can set a number of new standards for devices incorporated into new vehicles that will reduce the emissions of greenhouse gas air pollutants.[132]

III. THE ADMINISTRATOR HAS A MANDATORY DUTY TO REGULATE GREENHOUSE GASES UNDER THE CLEAN AIR ACT.

Having already made formal findings that the emission of air pollutants CO_2, CH_4, N_2O, and HFCs from mobile sources poses actual or potential harmful effects of the public health and welfare,[133] the Administrator must exercise her authority to regulate the emissions of CO_2, CH_4, N_2O, and HFCs, from new motor vehicles under § 202(a)(1). Section 202(a) states that the Administrator "shall by regulation prescribe . . . standards applicable to any air pollutant from any . . . class or classes of new motor vehicles" (emphasis added). Prior court decisions have found that the use of "shall" in § 202 creates a mandatory duty to promulgate standards.[134] Accordingly, the Administrator must act to implement the standards requested by this petition.

Further, even should the agency believe that there are scientific uncertainties regarding the actual impacts from global

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[132] For example, such standards could even include such things as tire efficiency standards.

[133] See supra, Argument I (a) & (b).

[134] NRDC v. Reilly, 983 F.2d 259, 266-67 (D.C. Cir. 1993) (finding that use of "shall" in § 202(a)(6) mandated promulgation of standards requiring new light duty vehicles be equipped with onboard refueling vapor recovery systems); See also, Hewitt v. Helms, 459 U.S. 460, 471, 74 L.Ed.2d 675, 103 S.Ct. 864 (1983)("shall" is "language of an unmistakably mandatory character"); Her Majecty the Queen v. EPA, 912 F.2d 1525, 1533 (D.C. Cir. 1990) ("shall" signals mandatory action).

warming, the precautionary purpose of the CAA supports actions regulating of these gases. In Lead Industries Assoc., Inc. v. EPA, the court explained that:

> requiring EPA to wait until it can conclusively demonstrate that a particular effect is adverse to health before it acts is inconsistent with both the Act's precautionary and preventive orientation and the nature of the Administrator's statutory responsibilities . . . Congress directed the Administrator to err on the side of caution in making the necessary decisions.[135]

The Administrator's authority to use precaution when regulating air pollutants is also elaborated upon in Ethyl Corp. v. EPA.[136] In this case, the court stated that "[t]he Administrator may apply [her] expertise to draw conclusions from suspected, but not completely substantiated relationships between facts, from trends among facts, from theoretical projects from imperfect data, from probative preliminary data not yet certifiable as fact, and the like."[137] Thus, the Administrator's clear mandate to regulate greenhouse gases under § 202 cannot be excused by a post hoc rationalization of scientific uncertainty.

Based upon, *inter alia*, the evidence presented herein, the petitioners request the Administrator to immediately begin regulating the emissions of the greenhouse gases - CO_2, CH_4, N_2O, and HFCs - from new motor vehicles as required by § 202(a)(1). Should the Administrator not undertake this mandatory duty, her inaction can be subject to judicial review.

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[135] 647 F.2d 1130, 1155 (D.C. Cir. 1980).

[136] 541 F.2d 1 (D.C. Cir.) (en banc), *cert. denied*, 426 U.S. 941 (1976).

[137] Id. at 28.

CONCLUSION

WHEREFORE, petitioners request that the Administrator:[138]

(1). Regulate the emissions of carbon dioxide (CO_2) from new motor vehicles and new motor vehicle engines under § 202(a)(1) of the Clean Air Act;

(2). Regulate the emissions of methane (CH_4) from new motor vehicles and new motor vehicle engines under § 202(a)(1) of the Clean Air Act;

(3). Regulate the emissions of nitrous oxide (N_20) from new motor vehicles and new motor vehicle engines under § 202(a)(1) of the Clean Air Act;

(4). Regulate the emissions of hydrofluorocarbons (HFCs) from new motor vehicles and new motor vehicle engines under § 202(a)(1) of the Clean Air Act;

As required by law, the EPA is required to give this petition prompt consideration. Additionally, under the Administrative Procedure Act "agency action" is defined to include "the whole or part of an agency rule, order, license, sanction, relief, or the equivalent denial thereof, *or failure to act.*" Therefore, petitioners are requesting a substantive response to this petition within one hundred eighty (180) calender days.[139] In the absence of an affirmative response, petitioners will be compelled to consider litigation in order to

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[138] Rulemaking undertaken pursuant to this petition must comply with the requirements contained in § 307(d), 42 U.S.C. § 7607(d).

[139] Petitioners note that a response period of 180 days is reasonable under the APA. See, 42 U.S.C. § 7604(a) requiring notice of 180 days prior to commence of an action for unreasonable delay. See also, 21 C.F.R. §10.30(e)(2) (1998) (FDA's implementation of the Administrative Procedure Act's petitioning provisions).

achieve the agency actions requested.[140]

Respectfully submitted,

s/

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Mr. Robert Perciasepe
Assistant Administrator
Office of Air and Radiation

[140] Petitioners also assert that through the filing of this petition they have complied with citizen suit notice requirements established in § 304, 42 U.S.C. § 7604..

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[from EPA administrative record]
[USEPA Symbol]

UNITED STATES ENVIRONMENTAL PROTECTION
AGENCY
WASHINGTON, D.C. 20460

Office of
General Counsel

April 10, 1998 [date stamped]

MEMORANDUM

SUBJECT: EPA's Authority to Regulate Pollutants Emitted by Electric Power Generation Sources

FROM: Jonathan Z. Cannon /s
General Counsel

TO: Carol M. Browner
Administrator

I. Introduction and Background

This opinion was prepared in response to a request from Congressman DeLay to you on March 11, 1998, made in the course of a Fiscal Year 1999 House Appropriations Committee Hearing. In the Hearing, Congressman Delay referred to an EPA document entitled "Electricity Restructuring and the Environment: What Authority Does EPA Have and What Does It Need." Congressman Delay read several sentences from the document stating that EPA currently has authority under the Clean Air Act (Act) to establish pollution control requirements

for four pollutants of concern from electric power generation: nitrogen oxides (NO_x), sulfur dioxide (SO_2), carbon dioxide (CO_2) and mercury. He also asked whether you agreed with the statement, and in particular, whether you thought that the Clean Air Act allows EPA to regulate emissions of carbon dioxide. You agreed with the statement that the Clean Air Act grants EPA broad authority to address certain pollutants, including those listed, and agreed to Congressman Delay's request for a legal opinion on this point. This opinion discusses EPA's authority to address all four of the pollutants at issue in the colloquy, and in particular, CO_2 which was the subject of Congressman DeLay's specific question.

The question of EPA's legal authority arose initially in the context of potential legislation addressing the restructuring of the utility industry. Electric power generation is a significant source of air pollution, including the four pollutants addressed here. On March 25, 1998, the Administration announced a Comprehensive Electricity Competition Plan (Plan) to produce lower prices, a cleaner environment, increased innovation and government savings. This Plan includes a proposal to clarify EPA's authority regarding the establishment of a cost-effective interstate cap and trading system for NO_x reductions addressing the regional transport contributions needed to attain and maintain the primary National Ambient Air Quality Standards (NAAQS) for ozone. The Plan does not ask Congress for authority to establish a cap and trading system for emissions of carbon dioxide from utilities as part of the Administration's electricity restructuring proposal. The President has called for cap-and-trade authority for greenhouse gases to be in place by 2008, and the Plan states that the Administration will consider in consultation with Congress the legislative vehicle most appropriate for that purpose.

As this opinion discusses, the Clean Air Act provides EPA authority to address air pollution, and a number of specific provisions of the Act are potentially applicable to control these pollutants from electric power generation. However, as was made clear in the document from which Congressman Delay quoted, these potentially applicable provisions do not easily lend themselves to establishing market-based national or regional cap-and-trade programs, which the Administration favors for addressing these kinds of pollution problems.

II. Clean Air Act Authority

The Clear Air Act provides that EPA may regulate a substance if it is (a) an "air pollutant," and (b) the Administrator makes certain findings regarding such pollutant (usually related to danger to public health, welfare, or the environment) under one or more of the Act's regulatory provisions.

A. Definition of Air Pollutant

Each of the four substances of concern as emitted from electric power generating units falls within the definition of "air pollutant" under section 302(g). Section 302(g) defines "air pollutant" as

> any air pollution agent or combination of such agents, including any physical, chemical, biological, [or] radioactive . . . substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent that the Administrator has identified such precursor or precursors for the particular purpose for which the term "air pollutant" is used.

This broad definition states that "air pollutant" includes any physical, chemical, biological, or radioactive substance or matter that is emitted into or otherwise enters the ambient air. SO_2, NO_x, CO_2 and mercury from electric power generation are each a "physical [and] chemical . . . substance which is emitted into . . . the ambient air," and hence, each is an air pollutant within the meaning of the Clean Air Act.[1]

A substance can be an air pollutant even though it is naturally present in air in some quantities. Indeed, many of the pollutants that EPA currently regulates are naturally present in the air in some quantity and are emitted from natural as well as anthropogenic sources. For example, SO_2 is emitted from geothermal sources; volatile organic compounds (precursors to ozone) are emitted by vegetation; and particulate matter and NO_x are formed from natural sources through natural processes, such as naturally occurring forest fires. Some substances regulated under the Act as hazardous air pollutants are actually necessary in trace quantities for human life, but are toxic at higher levels or through other routes of exposure. Manganese and selenium are two examples of such pollutants. EPA regulates a number of naturally occurring substances as air pollutants, however, because human activities have increased the quantities present in the air to levels that are harmful to public health, welfare, or the environment.

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[1] See also section 103(g) of the Act (authorizes EPA to conduct a basic research and technology program to develop and demonstrate nonregulatory strategies and technologies for air pollution prevention, which shall include among the program elements "[i]mprovements in nonregulatory strategies and technologies for preventing or reducing multiple air pollutants, including sulfur oxides, nitrogen oxides, heavy metals, PM-10 (particulate matter), carbon monoxide, and carbon dioxide, from stationary sources, including fossil fuel power plants.").

B. EPA Authority to Regulate Air Pollutants

EPA's regulatory authority extends to air pollutants, which, as discussed above, are defined broadly under the Act and include SO_2, NO_x, CO_2, and mercury emitted into the ambient air. Such a general statement of authority is distinct from an EPA determination that a particular air pollutant meets the specific criteria for EPA action under a particular provision of the Act. A number of specific provisions of the Act are potentially applicable to these pollutants emitted from electric power generation.[2] Many of these specific provisions for EPA

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[2] See, e.g.,section 108 (directs Administrator to list and issue air quality criteria for each air pollutant that causes or contributes to air pollution that may reasonably be anticipated to endanger public health or welfare and that is present in the ambient air due to emissions from numerous or diverse mobile or stationary sources); section 109 (directs Administrator to promulgate national primary and secondary ambient air quality standards for each air pollutant for which there are air quality criteria, to be set at levels requisite to protect the public health with an adequate margin of safety (primary standards) and to protect welfare (secondary standards)); Section 110 (requires states to submit state implementation plans (SIPs) to meet standards); section 111(b) (requires Administrator to list, and set federal performance standards for new sources in, categories of stationary sources that cause of contribute significantly to air pollution that may reasonably be anticipated to endanger public health or welfare); section 111(d) (states must establish performance standards for existing sources for any air pollutant (except criteria pollutants or hazardous air pollutants) that would be subject to a performance standard if the source were a new source); section 112(b) (lists 188 hazardous air pollutants and authorizes Administrator to add pollutants to the list that may present a threat of adverse human health effects or adverse environmental effects); section 112(d) requires Administrator to set emissions standards for each category or subcategory of major and area sources that the Administrator has listed pursuant to section 112(c)); section 112(n)(1)(A) (requires Administrator to study and report to Congress on the public health hazards reasonably anticipated from emissions of listed hazardous air pollutants from electric utility steam

(continued...)

action share a common feature in that the exercise of EPA's authority to regulate air pollutants is linked to a determination by the Administrator regarding the air pollutants' actual or potential harmful effects on public health, welfare or the environment. See, e.g., sections 108, 109, 111(b), 112, and 115. See also sections 202(a), 211(c), 231, 612, and 615. The legislative history of the 1977 Clean Air Act Amendments provides extensive discussion of Congress' purposes in adopting the language used throughout the Act referencing a reasonable anticipation that a substance endangers public health or welfare. One of these purposes was "[t]o emphasize the preventative or precautionary nature of the act, i.e., to assure that regulatory action can effectively prevent harm before it occurs; to emphasize the predominant value of protection of public health." H.R. Rep. No. 95-294, 95th Cong., 1st Sess., at 49 (Report of the Committee on Interstate and Foreign Commerce). Another purpose was "[t]o assure that the health of susceptible individuals, as well as healthy adults, will be encompassed in the term 'public health,' . . . ." Id. at 50. "Welfare" is defined in section 302(h) of the Act, which states:

> [a]ll language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility, and

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[2] (...continued)
generating units, and requires regulation if appropriate and necessary); section 115 (Administrator may require state action to control certain air pollution if, on the basis of certain reports, she has reason to believe that any air pollutant emitted in the United States causes or contributes to air pollution that may be reasonably anticipated to endanger public health or welfare in a foreign country that has given the United States reciprocal rights regarding air pollution control); Title IV (establishes cap-and-trade system for control of SO_2 from electric power generation facilities and provides for certain controls on NO_x).

> climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants.[3]

EPA has already regulated SO_2, NO_x and mercury based on determinations by EPA or Congress that these substances have negative effects on public health, welfare, or the environment. While CO_2, as an air pollutant, is within EPA's scope of authority to regulate, the Administrator has not yet determined that CO_2 meets the criteria for regulation under one or more provisions of the Act. Specific regulatory criteria under various provisions of the Act could be met if the Administrator determined under one or more of those provisions that CO_2 emissions are reasonably anticipated to cause or contribute to adverse effects on public health, welfare, or the environment.

C. EPA Authority to Implement an Emissions Cap-and-Trade Approach

The specific provisions of the Clean Air Act that are potentially applicable to control emissions of the pollutants discussed here can largely be categorized as provisions relating to either state programs for pollution control under Title I (e.g., sections 107, 108, 109, 110, 115, 126, and Part D of Title I), or national regulation of stationary sources through technology-based standards (e.g., sections 111 and 112). None of these provisions easily lends itself to establishing market-based

[3] The language in section 302(h) listing specific potential effects on welfare, including the references to weather and climate, dates back to the 1970 version of the Clean Air Act.

national or regional emissions cap-and-trade programs.[4]

The Clean Air Act provisions relating to state programs do not authorize EPA to require states to control air pollution through economically efficient cap-and-trade programs and do not provide full authority for EPA itself to impose such programs. Under certain provisions in Title I, such as section 110, EPA may facilitate regional approaches to pollution control and encourage states to cooperate in a regional, cost-effective emissions cap-and-trade approach (see Notice of Proposed Rulemaking: Finding of Significant Contribution and Rulemaking for Certain States in the Ozone Transport Assessment Group Region for Purposes of Reducing Regional Transport of Ozone, 62 F.R. 60318 (Nov. 7, 1997)). EPA does not have authority under Title 1 to require states to use such measures, however, because the courts have held that EPA cannot mandate specific emission control measures for states to use in meeting the general provisions for attaining ambient air quality standards. See Commonwealth of Virginia v. EPA, 108 F.3d 1397 (D.C. Cir. 1997). Under certain limited circumstances where states fail to carry out their responsibilities under Title 1 of the Clean Air Act, EPA has authority to take certain actions, which might include establishing a cap-and-trade program.[5] Yet EPA's ability to

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[4] Title IV of the Act provides explicit authority for a cap and trade program for SO_2 emissions from electric power generating sources.

[5] For example, section 110(c) requires EPA to promulgate a Federal implementation plan where EPA finds that a state has failed to make a required submission of a SIP or that the SIP or SIP revision does not satisfy certain minimum criteria, or EPA disapproves the SIP submission in whole or part. In addition, section 126 provides that a State or political subdivision may petition the Administrator for certain findings regarding emissions from certain stationary sources in another state. If the Administrator grants the petition, she may establish control requirements applicable to sources that

(continued...)

invoke these provisions for federal action depends on the actions or inactions of the states.

Technology-based standards under the Act directed to stationary sources have been interpreted by EPA not to allow compliance through intersource cap-and-trade approaches. The Clean Air Act provisions for national technology-based standards under sections 111 and 112 require EPA to promulgate regulations to control emissions of air pollutants from stationary sources. To maximize the opportunity for trading of emissions within a source, EPA has defined the term "stationary source" expansively, such that a large facility can be considered a "source." Yet EPA has never gone so far as to define as a source a group of facilities that are not geographically connected, and EPA has long held the view that trading across plant boundaries is impermissible under sections 111 and 112. See, e.g., National Emission Standards for Hazardous Air Pollutants for Source Categories; Organic Hazardous Air Pollutants from the Synthetic Organic Chemical Manufacturing Industry, 59 Fed. Reg. 19402 at 19425-26 (April 22, 1994).

III. Conclusion

EPA's regulatory authority under the Clean Air Act extends to air pollutants, which, as discussed above, are defined broadly under the Act and include SO_2, NO_x, CO_2 and mercury emitted into the ambient air. EPA has in fact already regulated each of these substances under the Act, with the exception of CO_2. While CO_2 emissions are within the scope of EPA's authority to regulate, the Administrator has made no determination to date to exercise that authority under the specific criteria provided under any provision of the Act.

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[5] (...continued)
were the subject of the petition.

With the exception of the SO_2 provisions focused on acid rain, the authorities potentially available for controlling these pollutants from electric power generating sources do not easily lend themselves to establishing market-based national or regional cap-and-trade programs, which the Administration favors for addressing these kinds of pollution problems. Under certain limited circumstances, where states fail to carry out their responsibilities under Title 1 of the Act, EPA has authority to take certain actions, which might include establishing a cap-and-trade program. However, such authority depends on the actions or inactions of the states.

[from EPA administrative record]

TESTIMONY OF
GARY S. GUZY
GENERAL COUNSEL
U.S. ENVIRONMENTAL PROTECTION AGENCY
BEFORE A JOINT HEARING OF THE
SUBCOMMITTEE ON NATIONAL ECONOMIC GROWTH,
NATURAL RESOURCES AND REGULATORY AFFAIRS
OF THE
COMMITTEE ON GOVERNMENT REFORM
AND THE
SUBCOMMITTEE ON ENERGY AND ENVIRONMENT OF
THE COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES

October 6, 1999

Thank you, Chairman McIntosh, Chairman Calvert, and Members of the Subcommittees, for the invitation to appear here today. I am pleased to have this opportunity to explain the U.S. Environmental Protection Agency's (EPA) views as to the legal authority provided by the Clean Air Act (Act) to regulate emissions of carbon dioxide, or CO_2.

Before I do, however, I would like to stress, as EPA repeatedly has stated in letters to Chairman McIntosh and other Members of Congress, that the Administration has no intention of implementing the Kyoto Protocol to the United Nations Framework Convention on Climate Change prior to its ratification with the advice and consent of the Senate.1 As I indicated in my letter of September 17, 1999 to Chairman

McIntosh, there is a clear difference between actions that carry out authority under the Clean Air Act or other domestic law, and actions that would implement the Protocol. Thus, there is nothing inconsistent in assessing the extent of current authority under the Clean Air Act and maintaining our commitment not to implement the Protocol without ratification.

Some brief background information is helpful in understanding the context for this question of legal authority. In the course of generating electricity by burning fossil fuels, electric power plants emit into the air multiple substances that pose environmental concerns, several of which are already subject to some degree of regulation. Both industry and government share an interest in understanding how different pollution control strategies interact. These interactions are both physical (strategies for controlling emissions of one substance can affect emissions of others) and economic (strategies designed to address two or more substances together can cost substantially less than strategies for individual pollutants that are designed and implemented independently). EPA has worked with a broad array of stakeholders to evaluate multiple-pollutant control strategies for this industry in a series of forums, dating back to the Clean Air Power Initiative (CAPI) in the mid-1990's. While the CAPI process focused on SO_2 and NO_x, a broad range of participants, including representatives of power generators, the United Mine Workers, and environmentalists, expressed support for inclusion of CO_2 emissions, along with SO_2, NO_x, and mercury, in subsequent analyses. One conclusion that emerged from these analytical efforts is that integrated strategies using marked-based "cap-and-trade" approaches like the program currently in place to address acid rain would be the most flexible and lowest cost means to control multiple pollutants from these sources.

On March 11, 1998, during hearings on EPA's FY 1999

appropriations, Representative DeLay asked the Administrator whether she believed that EPA had authority to regulate emissions of pollutants of concern from electric utilities, including CO_2. She replied that the Clean Air Act provides such authority, and agreed to Representative Delay's request for a legal opinion on this point.

Therefore, my predecessor, Jonathan Z. Cannon, prepared a legal opinion for EPA Administrator Carol Browner on the question of EPA's legal authority to regulate several pollutants, including CO_2 emitted by electric power generation sources. The legal opinion requested by Rep. DeLay was completed on April 10, 1998. It addressed the Clean Air Act authority to regulate emissions of four pollutants of concern from electric power generation: nitrogen oxides (NO_x), sulfur dioxide (SO_2), mercury, and CO_2. Because today's hearing is focused exclusively on CO_2, I will summarize the opinion's conclusions only as they relate to that substance.

The Clean Air Act includes a definition of the term "air pollutant," which is the touchstone of EPA's regulatory authority over emissions. Section 302(g) defines "air pollutant" as

> any air pollution agent or combination of such agents, including any physical, chemical, biological, [or] radioactive . . . substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant, to the extent that the Administrator has identified such precursor or precursors for the particular purpose for which the term "air pollutant" is used.

Mr. Cannon noted that CO_2 is a "physical [and] chemical substance which is emitted into . . . the ambient air," and thus

is an "air pollutant" within the Clean Air Act's definition. Congress explicitly recognized emissions of CO_2 from stationary sources, such as fossil fuel power plants, as an "air pollutant"in section 103(g) of the Act, which authorizes EPA to conduct a basic research and technology program to include, among other things, "[i]mprovements in nonregulatory strategies and technologies for preventing or reducing multiple *air pollutants, including* sulfur oxides, nitrogen oxides, heavy metals, PM-10 (particulate matter), carbon monoxide, *and carbon dioxide*, from stationary sources, including fossil fuel power plants." (Emphasis added.)

The opinion explains further that the status of CO_2 as an "air pollutant" is not changed by the fact that CO_2 is a constituent of the natural atmosphere. In other words, a substance can be an "air pollutant" under the Clean Air Act's definition even if it has natural sources in addition to its man-made sources. EPA regulates a number of naturally-occurring substances as air pollutants because human activities have increased the quantities present in the air to levels that are harmful to public health, welfare, or the environment. For example, SO_2 is emitted from geothermal sources; volatile organic compounds (VOCs), which are precursors to harmful ground-level ozone, are emitted by vegetation. Some substances regulated under the Act as hazardous air pollutants are actually necessary in trace quantities for human life, but are toxic at higher levels or through other routes of exposure. Manganese and selenium are two examples of such pollutants. Similarly, in the water context, phosphorus is regulated as a pollutant because although it is a critical nutrient for plants, in excessive quantities it kills aquatic life in lakes and other water bodies.

While CO_2, as an "air pollutant," is within the scope of the regulatory authority provided by the Clean Air Act, this by itself does not lead to regulation. The Clean Air Act includes

a number of regulatory provisions that may potentially be applied to an air pollutant. But before EPA can actually issue regulations governing a pollutant, the Administrator must first make a formal finding that the pollutant in question meets specific criteria laid out in the Act as prerequisites for EPA regulation under its various provisions. Many of these specific Clean Air Act provisions for EPA action share a common feature in that the exercise of EPA's authority to regulate air pollutants is linked to a determination by the Administrator regarding the air pollutant's actual or potential harmful effects on public health, welfare or the environment. For example, EPA has authority under section 109 of the Act to establish National Ambient Air Quality Standards for any air pollutant for which the Administrator has established air quality criteria under section 108. Under section 108, the Administrator must first find that the air pollutant in question meets several criteria, including that:

> it causes or contributes to "air pollution which may reasonably be anticipated to endanger public health or welfare," and
>
> its presence in the ambient air "results from numerous or diverse mobile or stationary sources . . ."

Section 302(h), a provision dating back to the 1970 version of the Clean Air Act, defines "welfare" and states:

> all language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, weather, visibility, and climate, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination

with other air pollutants.

Thus, since 1970, the Clean Act has included effects on "climate" as a factor to be considered in the Administrator's decision as to whether to list an air pollutant under section 108.

Analogous threshold findings are required before the Administrator may establish new source performance standards for a pollutant under section 111, list and regulate the pollutant as a hazardous air pollutant under section 112, or regulate its emission from motor vehicles under Title II of the Act.

Given the clarity of the statutory provisions defining "air pollutant" and providing authority to regulate air pollutants, there is no statutory ambiguity that could be clarified by referring to the legislative history. Nevertheless, I would note that Congress' decision in the 1990 Amendments not to adopt additional provisions directing EPA to regulate greenhouse gases by no means suggests that Congress intended to limit *pre-existing* authority to address any air pollutant that the Administrator determines meets the statutory criteria for regulation under a specific provision of the Act.

I would like today to reiterate one of the central conclusions of the Cannon memorandum, which stated: "While CO_2, as an air pollutant, is within EPA's scope of authority to regulate, the Administrator has not yet determined that CO_2 meets the criteria for regulation under one or more provisions of the Act." That statement remains true today. EPA has not made any of the Act's threshold findings that would lead to regulation of CO_2 emissions from electric utilities or, indeed, from any source. The opinion of my predecessor simply clarifies--and I endorse this opinion--that CO_2 is in the class of compounds that could be subject to several of the Clean Air Act's regulatory approaches. Thus, I would suggest that many of the concerns raised about the statutory authority to address CO_2 relate more

to factual and scientific, rather than legal, questions regarding whether and how the criteria for regulation under the Clean Air Act could be satisfied.

I also want to note, however, EPA has strongly promoted voluntary partnerships to reduce emissions of greenhouse gases through the EnergyStar and Green Lights programs and other non-regulatory programs that Congress has consistently supported. These successful programs already have over 7,000 voluntary partners who are taking steps to reduce greenhouse gas emissions, reduce energy costs and help address local air pollution problems. These programs also help the United States meet its obligations under the United Nations Framework Convention on Climate Change, which was ratified in 1992. I would also note, as EPA has indicated in past correspondence withe Chairman McIntosh and others, in the course of carrying out the mandates of the Clean Air Act, EPA has in a few instances directly limited use or emissions of certain greenhouse gases other than CO_2. For example, EPA has limited the use of certain substitutes for ozone-depleting substances under Title VI of the Act, where those substitutes have very high global warming potentials. I wish to stress once more, however, that while EPA will pursue efforts to address the threat of global warming through the voluntary programs authorized and funded by Congress and will carry out the mandates of the Clean Air Act, this Administration has no intention of implementing the Kyoto Protocol prior to its ratification on the advice and consent of the Senate.

This concludes my prepared statement. I would be happy to answer any questions that you may have.

[from EPA administrative record]

[US EPA Symbol]

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

Office of
General Counsel

December 1, 1999 [Date Stamped]

Honorable David M. McIntosh
Chairman, Subcommittee on National Economic Growth,
Natural Resources and Regulatory Affairs
Committee on Government Reform
U.S. House of Representatives
2157 Rayburn House Office Building
Washington, DC 20515-6143

Dear Mr. Chairman:

I am writing in response to your letter of October 14, 1999, which follows up on certain issues raised at the October 6, 1999, joint hearing conducted by the Government Reform

Subcommittee on National Economic Growth, Natural Resources and Regulatory Affairs and the Science Subcommittee on Energy and the Environment. Attached are our responses to your questions.

Please let me know if we can be of further assistance, or please have your staff contact Alexandra Teitz of my office at 202/564-5594.

Sincerely,

s/Gary S. Guzy

General Counsel

1. What in your judgement is the significance of the fact that the Clean Air Act refers to carbon dioxide (CO_2) only in reference to non-regulatory activities, such as research and technology development, while it specifically identifies hundreds of other substances to be regulated by the Environmental Protection Agency (EPA)?

In certain provisions of the Clean Air Act (CAA), Congress has delegated to EPA authority to regulate any air pollutant if the Administrator finds that the pollutant meets the criteria in the provision. For example, section 108 does not name any specific pollutants, but rather provides the criteria for EPA to use in determining whether to list and regulate a pollutant. In relevant part, the section requires the Administrator to list each air pollutant "emissions of which, . . . may reasonably be anticipated to endanger public health or welfare . . ." Section 112 contains a specific list of hazardous air pollutants, but also authorizes the Administrator to add other air pollutants to that list and provides the criteria for the Administrator to apply in making such determinations. A number of other Clean Air Act provisions are similarly structured. Specific mention of a pollutant in a statutory provision is not a necessary prerequisite to regulation under many CAA statutory provisions.

2. Your testimony cites Section 103(g) as proof that CO_2 is a "pollutant" within the meaning of the Clean Air Act. Yet, that very section directs the Administrator to develop "non-regulatory" strategies, and concludes with an admonition: "Nothing in this subsection shall be construed to authorize the imposition on any person of pollution control requirements." Similarly, the only provision of the Clean Air Act to mention global warming, section 602(e) stipulates: "The preceding sentence shall not be construed to be the basis of any additional regulation under this chapter." How do you interpret these Congressional

restrictions?

Congress explicitly recognized CO_2 emitted from stationary sources, such as fossil fuel power plants, as an "air pollutant" in section 103(g) of the Act, which authorizes EPA to conduct a basic research and technology program to include, among other things, "[i]mprovements in nonregulatory strategies and technologies for preventing or reducing multiple air pollutants, including . . . carbon dioxide, from stationary sources, ..." (Emphasis added.) EPA agrees that section 103(g) and section 602(e) do not themselves provide authority to regulate. However, the language that you have cited limiting the authority provided by those sections to research activities does not affect the fact that Congress recognized CO_2 as an air pollutant in section 103(g). Nor does the language in sections 103(g) and 602(e) limit in any way the regulatory authority provided by other provisions of the Clean Air Act.

3. During the hearing, Professor Jeffrey Miller argued that the absence of express statutory authority to regulate CO_2 is not significant because the Clean Air Act authorizes the Administrator to revise or add to the list of regulated substances. However, the Clean Air Act always confers such listing authority in the context of specific regulatory schemes designed to address specific kinds of problems. For example, there is a "criteria" pollutants program to reduce emissions of substances that adversely affect ambient air quality, a "hazardous" pollutants program to control emissions of toxic substances, and a stratospheric ozone protection program to phase out ozone-depleting substances. There is no comparable program to reduce, control, or phase-out emission of greenhouse gases. What in your judgement is the significance of the fact that the Clean Air Act contains no subchapter or section on global climate change? What is the significance of the fact that the

Act nowhere expressly authorizes the Administrator to list and promulgate regulations to control substances that may be reasonably anticipated to cause or contribute to global warming?

To answer your question, it is critical to understand how the structure of the Clean Air Act has evolved over time. The current Clean Air Act is the product of a series of enactments over the last 30 years, most importantly the amendments of 1970, 1977, and 1990. In the 1970 Clean Air Act, for example, Congress provided the Agency general authority to identify and regulate various types of air pollutants or sources (e.g., criteria pollutants under sections 108 and 109, new sources under section 111, or hazardous air pollutants under section 112). These 1970 provisions generally did not name specific pollutants or source types. EPA used those authorities in the following years to identify and set standards for a number of air pollutants (e.g., the National Ambient Air Quality Standards (NAAQS) for such air pollutants as ozone, sulfur dioxide, and particulate matter). After EPA took action under these general authorities, Congress has sometimes provided more specific authority. For example, the 1977 and 1990 amendments included specific mandates to periodically review and update the NAAQS that EPA had already set, and set forth refined approaches to the implementation of those standards. In this context it is not surprising to find 1977-and 1990-vintage provisions that specifically name ozone or other pollutants that EPA had already placed under regulation. In some areas, the 1977 and 1990 amendments include specific provisions mandating the regulation of one or more pollutants as to which EPA had not yet used its general authority. These more specific enactments generally left intact, and in some cases extended, EPA's general authority to identify and regulate additional air pollutants if they meet the criteria of relevant sections of the Act. Thus, the absence of specific provisions

addressing a particular air pollution problem does not mean that EPA lacks authority to address that problem.

Since 1970, the Clean Air Act has contained various provisions authorizing regulation to address air pollutants' actual or potential harmful effects on public health, welfare or the environment. For example, sections 107, 108, 109, 111(b), 112, 202, and 231, among others, date from the 1970 Act, although they have been modified since. The courts have long recognized that Congress need not address every question that could arise under a statutory scheme for an agency to have authority to act. "The power of an administrative agency to administer a congressionally created . . . program necessarily requires the formulation of policy and the making of rules to fill any gap left, implicitly or explicitly, by Congress. "*Chevron v. NRDC*, 467 U.S. 837, 843, (1984), *quoting Morton v. Ruiz*, 415 U.S. 199, 231 (1974)". In *Chevron*, the court discussed the variety of reasons why Congress might not have addressed a particular issue. "Perhaps that body consciously desired the Administrator to strike the balance at this level, thinking that those with great expertise and charged with responsibility for administering the provision would be in a better position to do so; perhaps it simply did not consider the question at this level; and perhaps Congress was unable to forge a coalition on either side of the question, and those on each side decided to take their chances with the scheme devised by the agency." *Id*. at 865. The court in *Chevron* recognized that Congress' failure to direct an agency on a specific issue, where Congress has given the agency broad power to act, constitutes an explicit or implicit delegation of authority for the agency to decide the issue. Thus, where Congress has provided EPA broad authority, with criteria for exercising such authority, the fact that Congress did not speak to how the Agency should exercise such authority with respect to each individual air pollutant or air pollution issue, does not limit EPA's delegated

authority.

4. In section 112 of the Clean Air Act, Congress specifically named 190 hazardous air pollutants (HAPs), but did not include CO_2 in the list. Each of the substances listed is highly toxic and endangers health or the environment through direct exposure, not indirectly through a chain of secondary effects as in the supposed case of greenhouse warming. By what scientific logic or statutory construction could EPA list CO_2 as a HAP?

EPA has not concluded that CO_2 is a hazardous air pollutant. As we have stated, EPA would have authority to regulate CO_2 under section 112 *if* a finding were made that CO_2 presented a threat of "adverse environmental effects," as section 112 uses that phrase. Section 112(a)(7) defines "adverse environmental effect" as "any significant and widespread adverse effect, which may reasonably be anticipated, to wildlife, aquatic life, or other natural resources, including adverse impacts on populations of endangered or threatened species or significant degradation of environmental quality over broad areas." Furthermore, air pollutants may be added to the list due to adverse environmental effects that occur not only through ambient concentrations, but also "bioaccumulation, deposition or otherwise." Thus, the substances that may be added to the list of hazardous air pollutants under section 112(b) are not limited to those that are "highly toxic and endanger[] health or the environment through direct exposure."

5. Could EPA have phased out Freon 12 and other non-toxic ozone-depleting substances under its authority to regulate HAPs, or did EPA require new and specific authority such as conferred by Subchapter VI? If the HAPs regulatory framework is unsuited to control substances that deplete the ozone layer, why is it not unsuited to control substances suspected of enhancing the greenhouse effect?

EPA has not evaluated whether it would have had authority to phase out ozone-depleting substances under section 112 of the Act. Congress gave EPA explicit and more detailed authority to address ozone-depleting substances under section 157 of the 1977 Clean Air Act and under Title VI of the Clean Air Act as Amended in 1990. Thus, the issue of whether EPA had authority under other provisions of the Act never arose.

6. Could EPA have phased out Freon 12 and other ozone-depleting substances under the National Ambient Air Quality Standards (NAAQS) program, or did EPA require new and specific authority such as conferred by Subchapter VI? If the NAAQS regulatory framework is unsuited to control substances that deplete the ozone layer, why is it not also unsuited to control substances suspected of enhancing the greenhouse effect?

EPA has not evaluated whether it has authority to phase out ozone-depleting substances under the NAAQS program. Please see the answer to question 5.

7. EPA contends that the NAAQS program is a potential source of authority to regulate emissions of CO_2. However as section 107(a) of the Clean Air Act makes clear, "ambient" air is that which surrounds people and communities in particular "geographic" areas or regions. Indeed, EPA's own definition of "ambient air" is "that portion of the atmosphere, external to buildings, to which the general public has access" (40 C.F.R. section 50.1(e)). In contrast, the supposed enhancement of the greenhouse effect by CO_2 emissions is a global phenomenon of the troposphere, a layer of the atmosphere to which the general public does not normally have access. Furthermore, CO_2 emissions have nothing to do with the "quality" (breathability or clarity) of ambient air. By what logic, then, might EPA ever classify CO_2 emissions as an "ambient

air quality" problem? By what logic might EPA ever regulate CO_2 under the same authority that it now regulates soot and smog?

It is important to note, as a threshold matter, that EPA does not have under active consideration use of the NAAQS provisions to regulate CO_2, as posed by this question. As stated in the April 10, 1998 Cannon memorandum on authority to regulate pollutants from electric power generation prepared for the Administrator and reiterated in my testimony, "[w]hile CO_2, as an air pollutant, is within EPA's scope of authority to regulate, the Administrator has not yet determined that CO_2 meets the criteria for regulation under one or more provisions of the Act." I further stated in my testimony that EPA has not proposed and has no current plans to propose to regulate CO_2.

That said, I would like to clarify several apparent misunderstandings regarding EPA's authority to establish national Ambient Air Quality Standards or take other actions under Title 1 of the Act.

First, your question appears to be premised on the proposition that the troposphere does not include the air at ground level, to which people ordinarily have access. It is our understanding, however, that the troposphere extends from the earth's surface up to a boundary layer some miles overhead that demarcates the lower reaches of the stratosphere (the "tropopause"). For example, a standard dictionary definition of the "troposphere" is: "[t]he lowest atmospheric region between the earth's surface and the tropopause." Webster's II New Riverside Dictionary. As you note, global warming is largely attributed to elevated levels of greenhouse gases in the troposphere.

Second, EPA currently regulates under Title I substances that are emitted and/or transported through parts of the troposphere above the height to which the public generally has access. For

example, humans generally do not have access to the area immediately surrounding the top of tall smoke stacks. Nor do people generally have access to the altitudes through which air pollutants travel as they mix and move to areas downwind.

Finally, the authority of sections 108 and 109 is not limited to pollutants that affect the "breathability or clarity. . . of ambient air." Sections 108 and 109 refer to adverse effects on public health, without specifying inhalation as the only relevant mode by which adverse health effects may be caused. Further, EPA is authorized to set national secondary ambient air quality standards "to protect the public welfare from any known or anticipated adverse effects associated with the presence of such air pollutant in the ambient air." Section 302(h) provides that "[a]ll language referring to effects on welfare includes, but is not limited to, effects on soils, water, crops, vegetation, man-made materials, animals, wildlife, *weather*, visibility, and *climate*, damage to and deterioration of property, and hazards to transportation, as well as effects on economic values and on personal comfort and well-being, whether caused by transformation, conversion, or combination with other air pollutants." (Emphasis added.) Thus, effects on climate would be a valid basis for a secondary NAAQS, and Congress' considerations were not limited solely to concerns about "breathability" or "clarity" of the air.

8. As noted, EPA defines "ambient air" for purposes of the NAAQS program as "that portion of the atmosphere, external to buildings, to which the general public has access" (40 C.F.R. section 50.1(e)). The general public does not normally have access to the troposphere, where CO_2 enhancement of the greenhouse effect supposedly occurs. Would EPA have to change this definition in order to promulgate a NAAQS for CO_2?

While EPA has not considered any of the specific regulatory

language that would be associated with promulgation of a NAAQS for CO_2, the question above appears likely to be an academic question, given the specific properties of greenhouse gases. We understand concentrations of greenhouse gases to be essentially identical between the portions of the troposphere to which the public has access and the portions of the troposphere to which it does not have access. Thus, measures addressed to limiting the concentration of greenhouse gases in the lower reaches of the troposphere would be identical to those intended to limit the concentration in the troposphere as a whole.

9. Assume for the sake of argument that EPA decided to publish a NAAQS for CO_2?

The types of questions posed below are ones that typically would be resolved through an extensive rulemaking process. For issues of this kind, such a process would typically include scientific studies, peer-review processes, legal and policy analyses, economic assessments, stakeholder involvement through meetings and public comments, and a proposed and final rulemaking. EPA has not begun such a rulemaking process, and the assumptions underlying this question and the following hypotheticals are not linked to any current or planned EPA activities. Thus, EPA believes it would be inappropriate for the Agency to speculate with regard to most of these questions before engaging in any rulemaking process. Responses are given below to those questions which can be answered without such speculation.

a. Would EPA set the NAAQS above or below the current atmospheric concentrations (360 parts per million) of CO_2?

Please see the response to question 9, above.

b. If EPA set the NAAQS above current concentrations, would not every area of the country be in attainment, even if U.S. CO_2 production suddenly doubled?

Please see the response to question 9, above.

c. If EPA set the NAAQS below current concentrations, would not every area of the country be out of attainment, even if all power plants and factories were to shut down?

Please see the response to question 9 above.

d. Has EPA ever published a NAAQS that, at the time of publication, put every area of the country either in attainment or out of attainment?

No, none of the NAAQS that EPA has published to date have, at the time of publication, put every area of the country either in attainment or out of attainment.

e. Is it EPA's contention that the NAAQS provisions of the Clean Air Act authorize designation of nonattainment areas where attainment cannot be achieved without coordinated international action? If the answer is yes, how could EPA assure attainment of a CO_2 NAAQS within the deadlines set forth in section 172(a)(2) if attainment depends on the actions of other countries?

EPA has not considered or taken a position on the question of whether the Clean Air Act authorizes designation of nonattainment areas where attainment cannot be achieved without international action. Thus, EPA also is unable to speculate on the second part of your question above. EPA notes, however, that Congress has contemplated that a situation could arise under the Clean Air Act in which an area would be unable to attain a NAAQS because of pollution transported from other countries. Section 179B provides that EPA must approve an implementation plan for such an area if the State establishes that the implementation plan would be adequate to attain and maintain the NAAQS, but for emissions emanating from outside of the U.S., thereby allocating an appropriate

portion of responsibility for the air pollution problem to the local area or region.

f. In light of the foregoing questions and your answers to them, does the NAAQS program have any rational application to a global phenomenon of the troposphere, such as the greenhouse effect? If your answer is yes, please describe the actions a State would be required to take in an implementation plan to demonstrate attainment of a CO_2 NAAQS set below current atmospheric concentrations.

EPA agrees that these are issues that would have to be resolved if the Agency were to consider setting a NAAQS for CO_2. As explained above, these issues would be addressed through an extensive rulemaking process, and hence they are not ones to which EPA can respond at this time. EPA also has not specifically evaluated the suitability of the NAAQS framework for regulating greenhouse gases. However, the April 10, 1998 Cannon memo noted that with respect to the control of emissions from electric power generating sources, the authorities potentially available under the Act "do not easily lend themselves to establishing market-based national or regional cap-and-trade programs, which the Administration favors for addressing these kinds of pollution problems."

10. Rep. John Dingell, in a letter to Rep. McIntosh dated October 5, 1999, states: "While it [section 103 of the Clean Air Act] refers, as noted in the EPA memorandum, to carbon dioxide as a 'pollutant,' House and Senate conferees never agreed to designate carbon dioxide as a pollutant for regulatory or other purposes." Mr. Dingell further states: "Based on my review of this history and my recollection of the discussions, I would have difficulty concluding that the House-Senate conferees, who rejected the Senate regulatory provisions (with the exception of the above-referenced

section 821)[1] contemplated regulating greenhouse gas emissions or addressing global warming under the Clean Air Act." Do you agree with Mr. Dingell's account of the legislative history? If not, please explain why.

EPA agrees with Congressman Dingell that Congress did not specifically address the question of regulation of CO_2 or greenhouse gas emissions in the 1990 Amendments. However, the relevant question here is whether the 1990 Amendments removed or limited in some way EPA's pre-existing general authority under various provisions of the Act to regulate air pollutants that meet the criteria for regulation under those specific provisions. The fact that Congress did not enact a proposed provision that would have mandated a pollutant's regulation on climate change grounds did not limit or revoke the general discretionary authority already contained in the Clean Air Act, prior to the 1990 Amendments.

11. Section 302(j) of the Clean Air Act defines "major stationary source" and "major emitting facility" as any stationary source or facility that emits 100 tons or more per year of any air pollutant. Has EPA estimated how many small-and mid-sized businesses and farms emit 100 tons or more of CO_2 per year? If so, how many? As "major sources" of CO_2 emissions, might not tens or even hundreds of thousands of small entities suddenly become subject to pollution control requirements, were EPA to regulate CO_2?

EPA has not undertaken any estimate of the number of small- and mid-sized business and farms that emit 100 tons or more of CO_2 per year. I would note, however, that some provisions of the Clean Air Act apply to "major stationary sources" and "major emitting facilities," but others do not.

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[1] **This section requires EPA to monitor - not control - CO_2 emissions from certain sources.**

12. At the hearing, the Subcommittees questioned you about the apparent contradiction between the Administration's commitment not to implement the Kyoto Protocol before ratification and EPA's claim of authority to regulate CO_2. Rep. Bob Barr asked: "Can you assure the Subcommittees that, even though EPA believes it already has the authority to regulate CO_2, EPA will not do so until and unless the Protocol is ratified? Can you give us that assurance?" You replied that "we have no plans to use our existing authority to regulate carbon dioxide." This is not very assuring, because your response may mean merely that EPA has no plans *at this time* to regulate CO_2. Please confirm or deny the following statements:

a. "EPA will not propose or issue rules, regulations, decrees, or orders to control emissions of CO_2, or prepare to control such emissions, until and unless the Kyoto Protocol is ratified."

Please see response to 12b. below.

b. "EPA will not spend taxpayer dollars to advocate or develop programs or initiatives designed to lay the groundwork for possible future regulation of CO_2 emissions, until and unless the Kyoto Protocol is ratified."

It would not be responsible for EPA to pledge under all circumstances not to exercise authorities or otherwise discharge responsibilities delegated to EPA by Congress for the purpose of protecting public health and the environment. However, I would like to reassure you again that EPA has no plans to use existing authority to regulate CO_2 emissions.

The Administration has repeatedly stated that it will not implement the Kyoto Protocol prior to Senate advice and consent to ratification. EPA has at all times complied, and will continue to comply, with the Knollenberg appropriations

restriction. As discussed in numerous pieces of previous correspondence, there is a clear and sound distinction, however, between implementation of the Kyoto Protocol and any of the appropriate actions regarding greenhouse gases under existing authorities for the purposes specified in the Clean Air Act, and in the 1992 Framework Convention on Climate Change, which was ratified by the Senate.

13. Rep. Barr also asked: "Are you saying that, if EPA determines that CO_2 emissions endanger public health, welfare, or the environment, EPA may regulate CO_2, even if the Senate does not ratify the Kyoto Protocol?" Your response did not address this question but rather reiterated EPA's general position the Clean Air Act "did cite carbon dioxide to be within the class of substances that could be subject to regulation." Therefore, please answer this question: Does EPA believe that the Administrations's promise not to implement the Kyoto Protocol prior to ratification is, *inter alia*, a promise not to regulate CO_2 emissions prior to ratification?

As noted above, and as we have repeatedly discussed in correspondence with you, there are many regulatory actions that have the effect, or even the purpose, of reducing greenhouse gases (sometimes including CO_2), but not the purpose of implementing the Kyoto Protocol. As we have explained in previous letters, some regulatory actions addressed to conventional air quality objectives (e.g., measures to address emissions of nitrogen oxides or sulfur dioxide) can have the indirect effect of reducing greenhouse gases, depending on technological approaches that individual firms choose for compliance. Some provisions of the Clean Air Act authorize regulatory actions that directly address emissions of greenhouse gases (e.g., certain provisions of Title VI). None of these actions has the purpose of implementing the Kyoto Protocol.

The Administrations's commitment not to implement the Kyoto Protocol prior to ratification is not a commitment to forego implementing the Clean Air Act. However, as stated above, EPA has no plans to use existing authority to regulate CO_2 emissions.

14. At the Hearing, you said that EPA has "not commenced the process" to determine whether CO_2 emissions endanger health, welfare, or the environment. This is puzzling. The Administration has said repeatedly that the science underpinning the Kyoto Protocol is "clear and compelling." Are we now to understand that the basic science issues are not "settled?" The actual test in the NAAQS for regulating a substance is whether, in the Administrator's "judgment," emissions of that substance "may reasonably be anticipated to endanger public health or welfare." Are you saying that, in the Administrator's judgement, there is no reasonable basis to anticipate that CO_2 emissions endanger public health or welfare?

As explained above in response to Question 9, in setting a new NAAQS, the Administrator exercises her judgement under sections 108 and 109 based on a record for rulemaking that includes a formal scientific review of the risks to public health and welfare. EPA has not commenced, with respect to CO_2, the formal scientific review process that is set forth in sections 108 and 109 regarding the setting of a new NAAQS. EPA believes, as do the other Parties to the ratified U.N. Framework Convention on Climate Change, that the science supporting international action on climate change is clear and compelling.

15. Your written testimony refers to CO_2 as a substance of environmental "concern." You also contend that CO_2 is a "pollutant" within the meaning of the Clean Air Act. Does EPA not feel obligated to conduct an analysis of pollutants of concern to determine if they should be regulated? Why

has EPA not "commenced" the process of making that determination? When will EPA begin that process?

As I have stated, EPA has no plans to use existing authority to regulate CO_2 emissions, and hence, has not commenced the actions that would be necessary to regulate CO_2 emissions.

16. Professor Jeffrey Miller states that EPA "could not promulgate a new source performance standard for carbon dioxide" under section 111 for any category of sources unless EPA could establish that a CO_2 emissions control technology "had been adequately demonstrated for such a category." To your knowledge, does there exist a commercially available, cost-effective technology to control CO_2 emissions from coal-fired power plants?

Standards under section 111 are not limited to the application of "end-of-pipe" pollution control technologies. Rather, they can include requirements as to the design or operation of a source, precombustion cleaning or treatment of fuels, and inherently low-polluting or non-polluting technologies. Regarding coal-fired power plants, one example of commercially available, cost-effective technology to control CO_2 emissions is a variety of measures to improve combustion efficiency ("heat rate improvements"). Heat rate improvements are currently being made at many such plants in response to the demand for greater efficiency as the electricity market moves towards competition. To say that controls exist that could be considered for adoption should EPA set NSPS for CO_2 is, of course, far from saying that EPA plans to adopt such standards. As outlined above, EPA has no such plans.

17. The Clean Air Act expressly requires EPA to set NAAQS for particulate matter and ozone. Nonetheless, the D.C. Appeals Court in *American Trucking Associations, Inc., et. al., v. EPA* held that EPA, in setting new NAAQS

for those substances, construed sections of the Clean Air Act "so loosely as to render them unconstitutional delegations of legislative authority." The Clean Air Act nowhere expressly authorizes EPA to regulate CO_2. Do you think EPA regulation of CO_2 would be challenged in court? If so, do you think the courts would uphold such regulation or strike it down as a usurpation of legislative power?

In response to the first question, while we cannot precisely predict the litigation strategy of private parties, it seems likely that any regulation of CO_2 would be challenged in court.

In order to respond to your second question, allow us to clarify several points regarding the NAAQS for particulate and ozone and the *American Trucking Association (ATA)* case. First, as you know, EPA has requested that the Justice Department appeal the *ATA* case and does not agree with its delegation ruling. Second, as indicated in prior answers, the 1970 Clean Air Act provided EPA with authority to issue NAAQS for particulate matter and ozone without specifically naming those pollutants in the statute. Subsequent amendments specifically require periodic review and revision of the named pollutants, while maintaining EPA's authority to add other pollutants to the list if the statutory criteria for listing are met. Even if the *ATA* decision were ultimately upheld, EPA believes it would retain the authority to list and regulate additional air pollutants if the appropriate findings were made and supported in a rulemaking record. It does not appear that the listing and regulation of additional pollutants would create any special or additional problems under the theory of the *ATA* case.

18. Your July 26, 1999 letter in response to Rep. McIntosh's letter of July 1st included an "Attachment M," which is marked "Draft" and dated "2/18/99." It is entitled "Summary of Appropriations Restriction" and it is unsigned. It discusses the fiscal year (FY) 1999 VA-HUD

and Independent Agencies Appropriations Act restriction and concludes: "EPA may expend funds to propose or issue a regulation for a number of purposes including the reduction of greenhouse gas emissions, as long as the expenditures are in implementation of existing law and not for the purpose of implementing, or in preparation for implementing, the Kyoto Protocol. EPA may also expend funds on authorized nonregulatory activities."

a. Do the Clean Air Act's regulatory provisions include the term "greenhouse gas emissions"? If so, please identify the specific provisions of the Act.

The Clean Air Act sections that provide the generic regulatory authority addressed in the April 10, 1998 Cannon memo and in Attachment M do not include the term "greenhouse gas emissions." Section 821 of the 1990 Clean Air Act amendments, which required promulgation of regulations requiring monitoring of CO_2 emissions from electric power plants, uses the term "greenhouse gases" in the title of the section.

b. Do you interpret the term "air pollutant" to encompass all greenhouse gases including, for example, water vapor?

Water vapor is the most abundant greenhouse gas and it contributes most to the natural greenhouse effect. Considering the abundance of water vapor from natural sources, it has not been concluded that human activities directly add amounts of water vapor to the atmosphere that have significantly changed its atmospheric concentrations. By contrast, human activities have caused atmospheric concentrations of CO_2, methane, and nitrous oxide to increase by more than 30%, 145%, and 15%, respectively, since pre-industrial times. The increasing concentrations of these gases are strengthening the greenhouse effect, which is expected to lead to global warming and climatic

changes. Thus, emissions of water vapor from human activities have not been a focus of U.S. or international activities to address climate change.

c. If you do interpret the term "air pollutant" to include all greenhouse gases, what is the basis for the above statement that EPA may expend funds to "propose or issue" regulations for "reduction of greenhouse gas emissions"?

Attachment M explains EPA's interpretation of the distinction between activities barred under the Knollenberg appropriations restriction and activities not barred by that provision. The full text of the sentence that you quote is: "EPA may expend funds to propose or issue a regulation for a number of purposes including the reduction of greenhouse gas emissions, as long as the expenditures are in implementation of existing law and not for the purpose of implementing, or in preparation for implementing, the Kyoto Protocol." The basis for this statement is that the appropriations restriction only limits the types of expenditures specified in the provision--regulatory activities for the purpose of implementation or in preparation for implementation of the Kyoto Protocol. Attachment M explains that to the extent that existing law authorizes regulation of greenhouse gas emissions and such regulations are not for the purpose of implementing or preparing to implement the Kyoto Protocol, issuance of such regulations would not be barred. Attachment M does not opine on the scope or source of any existing authority to regulate greenhouse gas emissions.

d. Which office prepared Attachment M? Did you review it?

The Office of General Counsel prepared, and after its preparation I had occasion to review, Attachment M.

e. What is the present status of Attachment M? Has it

been provided to Congress, other than Regulatory Affairs Subcommittee?

Attachment M was distributed within the Agency as internal guidance to EPA staff to ensure that they understood the restrictions imposed by the FY 1999 appropriations restriction. In addition to being provided to the Regulatory Affairs Subcommittee, this document was also provided to GAO on March 30, 1999.

19. In reply to questions by the House Science Committee about the Administration's new proposal for FY 2000 of a $200 million "Clean Air Partnership Fund," EPA declared that "CO_2 and other greenhouse gases" are "each" an air pollutant "within the meaning of the Clean Air Act." However, it is our understanding that the United Nations Framework Convention on Climate Change (UNFCCC), which was ratified after the Clean Air Act was last amended, does not classify greenhouse gases as "pollutants." Rather, the UNFCCC defines greenhouse gases as "those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and re-emit infrared radiation." (Art. 1.5).

a. Do you concur that the UNFCCC does not classify greenhouse gases as pollutants?

b. Is there a conflict between EPA's classification of CO_2 and other greenhouse gases as "pollutants" and the absence of such classification in the UNFCCC?

The UNFCCC is an international agreement under which member states have committed to taking certain actions and pursuing certain goals with respect to climate change. Member states continue to act, however, under domestic authorities, which may differ among member states and from the text of the international agreement. There is no reason why the Clean Air

Act's definition and use of the term "air pollutant" should be reflected in the UNFCCC, nor does the absence of such identical language in any way create a conflict. Moreover, as we note above, for Clean Air Act regulatory purposes the significant question is not whether a substance meets the definition of an "air pollutant," but whether it meets the criteria for regulation under a particular provision of the Clean Air Act. To be clear, we have not taken any steps under the Act to "classify" CO_2.

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON, D.C. 20460

Feb. 16, 2000[Date Stamped]

Office of
General Counsel

Honorable Ken Calvert
Chairman, Subcommittee on Energy and the Environment
Committee on Science
U.S. House of Representatives
Washington, DC 20515
Dear Mr. Chairman:

I am writing in response to your letter of December 10, 1999, regarding EPA authority with respect to climate change, which addresses certain issues from our letter of December 1, 1999, responding to your letter of October 14, 1999. Attached are our responses to your questions.

Please let me know if we can be of further assistance, or please have your staff contact Alexandra Teitz of my office at (202) 564-5594.

Sincerely,

s/ Gary S. Guzy
General Counsel

Attachment

1. Your response to Q1 of our October 14th letter states: "Specific mention of a pollutant in a statutory provision is not a necessary prerequisite to regulation under many CAA statutory provisions." That is correct, as we acknowledge in Q3 of our October 14th letter. Because a law cannot specify in advance all the circumstances to which it may apply, and because science continually brings to light new information regarding the health and environmental effects of particular air emissions, the Clean Air Act (CAA) sensibly allows the Environmental Protection Agency (EPA) *some* discretion to fill in gaps and address unforeseen contingencies as they arise. However, when Congress amended the CAA in 1990, it was quite familiar with the theory that man-made emissions of carbon dioxide ($CO_{2)}$ cause, or are likely to cause, global warming. Indeed, Congress had already held several hearings and debates on the subject, including some specifically intended to inform its deliberation on the CAA amendments. Thus, it is not the fact that the CAA nowhere lists CO_2 as a substance to be regulated, but does list numerous other substances, evidence that Congress, in 1990, decided to reserve to itself the power to determine, at some future date, whether or not EPA should regulate CO_2?

Please see in our December 1 letter our responses to Q1 and Q3 of your October 14 letter. In those responses, we discuss the development of the CAA over time and how this history informs our views on the significance of the fact that Congress did not in the 1990 Amendments require EPA to regulate CO_2. As we stated previously, specific mention of a pollutant in a statutory provision is not a necessary prerequisite to regulation under many CAA statutory provisions.

Congress did not in 1990 limit the potential applicability of any of the CAA regulatory provisions of $CO_{2.}$ Thus, in our view,

the CAA does not express a decision by Congress not to regulate CO_2 unless it should determine to do so at some future date.

2. Your response to Q2 of our October 14th letter states: "Nor does the language in sections 103(g) and 602(e) limit in any way the regulatory authority provided by other provisions of the Clean Air Act." These two sections are the only CAA provisions that mention CO_2 and global warming, and, as you acknowledge, they "do not themselves provide authority to regulate." Thus, your interpretation is paradoxical, to say the least. To wit; although sections that mention CO_2 and global warming do not provide authority to regulate greenhouse gasses, "other provisions" that are completely silent about CO_2 and global warming do provide such authority. We regard this interpretation as not only paradoxical but wrong, because it effectively negates the limitations on EPA's authority set forth in 103(g) and 602(e). After all, if "other provisions" already authorize EPA to regulate greenhouse gases, then the admonitions against assuming such authority in sections 103(g) and 602(e) are a practical nullity. If Congress intended to delegate to EPA the authority to regulate greenhouse gases, why did it admonish EPA not to assume such authority in the only CAA provisions dealing with CO_2 and global warming?

In section 103(g), Congress directed EPA to establish a program with the purpose of *demonstrating nonregulatory strategies* for pollution prevention. It makes sense that Congress did not intend for this provision to be construed to mandate or authorize a broad new regulatory program *mandating* pollution prevention. Similarly, section 602(e) is specifically targeted to providing *information* regarding the ozone-depletion potentials and global warming potentials of a

variety of substances. Again, Congress did not intend for this information provision to be construed to mandate or authorize a broad new regulatory program to regulate greenhouse gases. Neither of these provisions is structured to direct the exercise of regulatory authority. For example, neither contain criteria specifying the circumstances under which regulation is appropriate. By contrast, the regulatory provisions of the Act do specify such criteria and the structure of the regulations authorized by those provisions. Thus, it makes sense that Congress would not intend the Agency to regulate substances under authorities provided for nonregulatory activities. The language in sections 103(g) and 602(e) does not directly or indirectly limit the regulatory authorities provided to the Agency elsewhere in the Act. Nor does that language negate the fact that Congress explicitly recognized in these provision that CO_2 was an "air pollutant."

3. We do not find persuasive your response to Q3 of our October 14th letter. We asked: "What is the significance of the fact that the Act nowhere expressly authorized the Administrator to list and promulgate regulations to control substances that may be reasonably anticipated to cause or contribute to global warming?" You answered that the 1977 and 1990 CAA amendments "generally left intact, and in some cases extended, EPA's general authority to identify and regulate additional air pollutants if they meet the criteria of relevant sections of the Act. Thus, the absence of specific provisions addressing a particular air pollution problem does not mean that EPA lacks authority to address that problem." This response blurs the immense practical difference between the authority to list and regulate "additional air pollutants" within an established regulatory scheme and the authority to create new regulatory schemes.

A "particular air pollution problem" may be very specific

(e.g., the impact of carbon monoxide (CO) emissions from automobiles on ambient air quality) or very broad (e.g., the impact of all auto and industrial emissions on ambient air quality). Although we agree that EPA could list and control CO without a specific provision mentioning it, we do not agree that EPA could control CO without specific provisions authorizing EPA to protect ambient air quality. To put this in the language of *Chevron v. NRDC*, which you site, there is a world of difference between EPA filling in a "gap left, implicitly or explicitly, by Congress" in a "congressionally created . . .program" and EPA's arrogating to itself the power to create new programs. Adding a chemical to the list of ambient air pollutants, or the list of hazardous air pollutants, or the list of ozone-depleting substances, is merely filling "gaps" in "congressionally created" programs. However, Congress has never created a greenhouse gas emissions control program; it has never created a regulatory global warming mitigation program. Thus, if EPA were to attempt to bootstrap such a program into existence, citing CAA sections 108, 111, 112, or other provisions, this would not be an exercise in filling "gaps." It would be a usurpation of legislative power.

Therefore, please answer the following questions:

(a) Do you acknowledge that there is a vital practical distinction between filling gaps in existing programs and creating new programs?

As you use the term here, we are not certain what you would consider to constitute a distinct "program." One can identify practical differences between activities such as applying existing requirements to a new set of sources or additional pollutants, and setting up a new control regime to address a previously overlooked environmental problem from previously

unregulated sources, as the latter is likely to require greater Agency resources, public education efforts, etc. As long as both types of activities are authorized by law, we do not see a general legal distinction between them, however.

(b) Do you agree that EPA may not create new programs without clear and express Congressional authorization?

EPA may not act without Congressional authorization. We do not believe that the question of whether a "new program" is authorized by Congress would be addressed any differently from the question of whether any EPA activity is authorized by Congress.

(c) Do you believe that EPA's authority to control substances based upon their global warming potential is as clear and certain and unambiguous as EPA's authority to control substances based upon their impact on ambient air quality, their toxicity, or their potential to damage the ozone layer?

Whether EPA has authority to control any air pollutant under the CAA depends upon whether EPA finds that the pollutant meets the particular criteria for regulation specified under a provision of the Act. As EPA has no current plans to propose regulations for CO_2, EPA has not evaluated the strength of the technical and legal basis for such findings under any particular provision of the Act. Under section 612 of the Act, EPA has already addressed certain other substances that are substitutes for ozone-depleting substances based on their global warming potentials, and we believe we had clear authority for those steps.

4. Your response to Q4 of our October 14th letter argues that EPA could, in principle, regulate CO_2 as a hazardous air pollutant (HAP) because the class of hazardous air pollutants is "not limited to those that are highly toxic and

endanger health or the environment through direct exposure." You contend that all EPA has to do to list a substance as a HAP to determine that it has an "adverse environmental effect," defined in section 112(a)(7) as "any significant and widespread adverse effect" on "wildlife," "aquatic life," "other natural resources," or "environmental quality over broad areas." We disagree. Under that interpretation, EPA could regulate all ambient air pollutants and all ozone-depleting substances as HAPs. However, in section 112(b)(2), Congress took care to preclude any such expansive interpretation of EPA's authority to list and regulate HAPs. Section 112(b)(2) limits EPA's authority with respect to substances that have adverse environmental effects, and when that limitation is taken into account, it becomes clear that EPA cannot possibly list CO_2 as a HAP.

Section 112(b)(2) does indeed direct the Administrator to add pollutants to the list of HAPs that present a "threat of . . . adverse environmental effects," but with two important exceptions. First, "No [ambient] air pollutant which is listed under section 7408(a) [section 108(a)] of this title may be added to the list under this section," unless the pollutant "independently meets the listing criteria of this paragraph." Second, "No substance, practice, process or activity regulated under subchapter VI [on stratospheric ozone protection] of this chapter shall be subject to regulation under this section solely due to its adverse effects of the environment." In other words, the fact that ambient air pollutants such as CO_2, sulfur dioxide (SO_2), and particulate matter, or ozone-depleting substances such as Freon-12, may have a "significant and widespread adverse effect" on the environment is not sufficient warrant to [sic] classify them as HAPs. Those pollutants must also meet the independent criteria established by section 112.

Section 112 does not provide an exhaustive description of those criteria, using phrases ("including, but not limited to," "whether through ambient concentrations, bioaccumulation, deposition, or otherwise") that give EPA reasonable discretion to address unanticipated health or environmental threats. Nonetheless, section 112 mentions enough criteria to make intelligible the distinction between hazardous air pollutants, on the one hand, and either ambient air pollutants or ozone-depleting substances, on the other. Hazardous air pollutants include those that "are known to be, or may reasonably be anticipated to be, carcinogenic, mutagenic, teratogenic, neurotoxic, which cause reproductive dysfunction, or which are acutely or chronically toxic." Furthermore, the actual listing of some 190 HAPs in the statute is strong textual evidence of what Congress meant by "hazardous." Clearly, "hazardous air pollutants" are the nastiest of the nasties - or, as we said in our October 14th letter, substances that are "highly toxic and endanger[] health or the environment through direct exposure."

Several questions emerge from foregoing discussion:

(a) An ambient air pollutant like SO_2 may not be classified as a HAP unless it "independently meets the listing criteria" of section 112(b)(2). What are the criteria for listing under section 112 that SO_2 and the other ambient air pollutants do not independently meet?

Section 112(b)(2)provides: "No air pollutant which is listed under section 108(a) may be added to the list under this section, except that the prohibition of this sentence shall not apply to any pollutant which independently meets the listing criteria of this paragraph and is a precursor to a pollutant which is listed under section 108(a) or to any pollutant which is in a class of pollutants listed under such section." (Emphasis added.) Thus,

a pollutant already listed as a criteria pollutant under section 108(a) may be listed under section 112 only if it is a precursor to a criteria pollutant and it meets the criteria for listing under section 112(b)(2).

(b) Under what criteria might EPA list CO_2 as a HAP but not list any of the ambient air pollutants as HAPs?

EPA could list a pollutant as a HAP if the Administrator determined that it was a pollutant that may present, through inhalation or other routes of exposure, adverse human health effects or "adverse environmental effects whether through ambient concentrations, bioaccumulation, deposition, or otherwise." As noted above, EPA could not list a criteria pollutant listed under section 108 as a HAP unless it (1) was also a precursor to a criteria pollutant listed under section 108, and (2) met the criteria listed above. EPA could list a criteria pollutant as a HAP if it met both of these requirements.

(c) Section 112(b)(2) provides that no ozone-depleting substance shall be classified as a HAP "solely due to its adverse effects on the environment." If no ozone-depleting substance may be listed as a HAP solely due to its adverse environmental effects, does it not stand to reason that no greenhouse gas may be listed solely due to its adverse environmental effects? Indeed, is not the exemption of greenhouse gases from listing under section 112 even stronger than that for ozone-depleting substances, inasmuch as the CAA nowhere expressly authorized EPA to regulate greenhouse gases.

It appears that Congress precluded the listing of an ozone-depleting substance "solely due to its adverse effects on the environment" because Congress believed that those substances' environmental effects would be adequately addressed under Title VI. Congress left open the possibility that EPA could

issue regulations under section 112 if an ozone-depleting substance also has effects on public health that were not adequately addressed under Title VI. Since section 112 says nothing precluding the listing of greenhouse gases (or, for that matter, any other pollutants not regulated under Title VI) on environmental grounds alone, EPA does not agree with the conclusion in the last sentence of your question.

(d) Under what criteria might EPA list CO_2 as a HAP but not list Freon -12?

As noted above, EPA could not list Freon-12, which is an ozone-depleting substance covered by Title VI, as a HAP unless the Administrator determined that Freon-12 was a pollutant that may present, through inhalation or other routes of exposure, adverse human health effects. This limitation on the use of section 112 to address a pollutant covered by Title VI simply does not apply to CO_2.

5. In Q5 of our October 14th letter, we asked whether EPA could have phased out Freon-12 and other non-toxic ozone-depleting substances under its authority to regulate HAPs or whether EPA required new and specific authority, such as conferred by subchapter VI. We further asked whether, if the HAPs framework is unsuited to control substances that deplete the ozone layer, it might not also be unsuited to control substances suspected of enhancing the greenhouse effect. You replied, "EPA has not evaluated whether it would have had authority to phase out ozone-depleting substances under section 112 of the Act." We regard that answer an non-responsive. Our question was not whether EPA has or has not conducted an evaluation, but whether it has the authority in question. We think the answer to our question is clear. As noted above, section 112(b)(2)states: "No substance, practice, process or activity regulated under subchapter VI [on stratospheric ozone

protection] of this chapter shall be subject to regulation under this section solely due to its adverse effects on the environment." In short, the HAPs framework is unsuited to control substances that deplete the ozone layer. Do you agree?

Please see our answer above to question 4(c). We also note that Congress included on the section 112(b)(1) list of HAPs several substances that deplete the ozone layer (e.g. methyl bromide, carbon-tetrachloride ($CC1_4$).

6. In Q6 of our October 14th letter, we asked whether EPA could have phased out Freon-12 and other ozone-depleting substances under the National Ambient Air Qualitiy Standard (NAAQS) program, or whether EPA required new and specific authority, such as that conferred by subchapter VI. We further asked whether, if the NAAQS framework was unsuited to control ozone-depleting substances, it might not also be unsuited to control substances suspected of enhancing the greenhouse effect. You replied, "EPA has not evaluated whether it has authority to phase out ozone-depleting substances under the NAAQS program." We regard that answer also as non-responsive. Again, our question was not whether EPA has or has not conducted an evaluation, but whether it has the authority in question. Stratospheric ozone depletion is, by definition, a phenomenon of the stratosphere, not of the ambient air. Furthermore, from the standpoint of protecting the ozone layer, it matters not whether ozone-depleting chemicals such as chlorofluorocarbons are produced and used in California, Indiana, or Japan. In contrast, it matters a great deal where ambient air pollutants are released; and, consequently, the NAAQS program is organized by geographic region. Finally, to protect stratospheric ozone, it is not practical to monitor

and control ambient concentrations of ozone-depleting chemicals; rather, it is necessary to phase out and ban the production, trade, and use of such substances. In light of the foregoing considerations, do you believe the NAAQS program has any rational application to the issue of stratospheric ozone depletion?

Since Title VI adequately addresses stratospheric ozone depletion, EPA has not had any occasion or need to undertake an evaluation of the use of the NAAQS program to address this problem. In the absence of such an evaluation, we do not have anything further we can provide in answer to your question on this subject.

7. Thank you for pointing out that the "troposphere" begins at the planet's surface and, thus, includes "ambient air," as defined by EPA ("that portion of the atmosphere, external to buildings, to which the general public has access"). Nonetheless, we believe that Q7 of our October 14th letter identified a basic problem in EPA's position. As Peter Glaser testified at the October 6th joint hearing, "Although groundlevel and lower atmospheric ambient concentrations of carbon dioxide may differ slightly from locality to locality owing to differing sources and sinks, the greenhouse effect results from overall greenhouse gas concentrations in the troposphere rather than at groundlevel. Tropospheric levels of carbon dioxide over any particular locality are not influenced by emissions of carbon dioxide locally or upwind." Similarly, you observe that the troposphere extends upwards "to a boundary layer some miles overhead that demarcates the lower reaches of the stratosphere ('tropopause'), "i.e., well beyond the portion of the atmosphere to which the public has access. Ambient air is part of the troposphere, but most of the troposphere is not ambient air.

The conclusions we draw from these facts are: (a) the greenhouse effect, and its supposed enhancement by man-made CO_2 emissions are global phenomena of the troposphere, not local conditions of the ambient air; and, (b) the NAAQS program, because it targets local conditions of the ambient air, is unsuited to address the potential problem of global warming. Do you agree?

All of the nations of the world contribute to anthropogenic contributions to a global greenhouse effect, which occurs in the troposphere. To be precise, however, the greenhouse effect occurs throughout the troposphere, which includes the ambient air under EPA's definition. In the Memorandum from Jonathan Cannon to Carol Browner, April 10, 1998, my predecessor as General Counsel stated that the NAAQS provisions and other authorities potentially available for controlling four pollutants from electric power generating sources, which include CO_2, "do not easily lend themselves to establishing market-based national or regional cap-and-trade programs, which the Administration favors for addressing these kinds of pollution problems." This is not the same as a conclusion that the NAAQS provisions are totally "unsuited" for use to address CO_2. EPA has not reached any conclusion on this question because, as already noted, the Agency has not proposed and has no current plans to propose regulations for CO_2. Please see also our response to Q7 of your October 14th letter.

8. In your answer to Q7 or our October 14th letter, you argue, citing CAA section 302(h), that EPA may set "secondary" national ambient air quality standards to protect the public welfare from the known or anticipated effects of an air pollutant on "weather, visibility and climate." However, we understand that this language was adopted in the 1970 CAA amendments – more than a decade before global warming became a theme of public

and Congressional debate. Mr. Glaser informs us that, in 1970, Congress was concerned about the weather and climate impacts of particulate pollution, which, at the local or regional level, can impair visibility, increase precipitation through condensation, and cool ambient air temperatures by reflecting sunlight. We find this a reasonable interpretation of section 302(h), as the NAAQS program is suited to address the local or regional impacts particulates may have on weather, visibility and climate. However, section 302(h) provides no clue as to how the NAAQS program could be applied to CO_2 in the context of the issue of global warming. Do you agree that, when Congress included "weather, visibility and climate" in the 1970 CAA definition of "welfare," its intent was to address the local and regional effects of particulate pollution? Or, do you believe Congress intended that definition to cover global warming caused by emissions of greenhouse gases? If so, on the basis of what information does EPA reach that conclusion?

There is nothing in the text section 302(h) and we have found nothing in its legislative history to support Mr. Glaser's speculation that the scope of that provision was limited to local or regional air pollution problems. Section 302(h) itself indicates that "effects on welfare" are not limited to those listed, and the broad scope of the examples listed indicates that Congress intended to define the term broadly, in order to encompass both problems known at that time and unanticipated, potential problems that could be recognized thereafter. In fact, the legislative history of the 1970 amendments reflected Congressional awareness that there were "many gaps" in the scientific knowledge of welfare effects at the time, and the expectation that research on such effects would be intensified. S. Rep. No. 91-1196, 91st Cong., 2d Sess. 11 (1970). Such research was to extend to welfare effects " in

their broadest definition, including...visibility, weather, and climate." S. Rep. No. 91-1196, 91st Cong., 2d Sess. 7 (1970). The words of the statute indicate on their face that Congress was aware of the potential for air pollutants to have adverse effects on the weather and the climate, and not simply to be addressed solely due to inhalation.

9. Q9 of October 14th letter posed a series of "hypotheticals"designed to test whether the NAAQS program has any rational application to the issue of global warming. You argued that the "types of questions" we posed 'are ones that typically would be resolved through an extensive rule making process" involving "scientific studies, peer-review processes, legal and policy analyses, economic assessments, stakeholder involvement through meetings and public comments, and a proposed and final rule making." We disagree. The questions we posed are conceptual, not technical. They are the types of questions that EPA and other policymakers should address and satisfactorily resolve *before* the start of any rulemaking process.

A NAAQS for CO_2 would have to be set either *below, above,* or *at* current atmospheric concentrations. There is no other possibility. So, before a single dime of taxpayer money is expended on an "extensive rulemaking process," policymakers should think through whether setting a NAAQS for CO_2 makes any sense at all. As we see it, setting a NAAQS for CO_2 above the current concentrations would put the entire country in attainment, even if U.S. CO_2 production suddenly doubled. Conversely, setting a NAAQS for CO_2 below current concentrations would put the entire county out of attainment, even if all power plants and factories were to shut down. Setting a NAAQS for CO_2 at current concentrations would put the entire country in attainment -- but only temporarily. As soon as global

concentrations exceeded the NAAQS, the entire country would be out of attainment, no matter how stringent or costly the U.S. emission control regime might be.

From these considerations we conclude that the NAAQS program is fundamentally unsuited to address the issue of global warming. Do you agree?

Since EPA has no current plans to propose regulations for CO_2, the Agency has not fully evaluated the possible applicability of various CAA provisions for this purpose. At this point in time, your question is entirely hypothetical. Our previous response to Q.9 of your letter of October 14 indicated that certain aspects of your question, such as where EPA would set a NAAQS for CO_2 under this hypothetical rulemaking, would properly be addressed through a rulemaking process. Please see also our response to Q.7 above.

10. In your answer to Q9e of our October 14th letter, you state that "EPA has not considered or taken a position on the question of whether the Clean Air Act authorizes designation of nonattainment areas where attainment cannot be achieved without international action." This seems to us a significant admission by EPA, because attainment of a NAAQS for CO_2 would clearly be impossible without extensive international action. Until EPA resolves that question in the affirmative, it is not premature to claim, as EPA does, that section 108 of CAA is "potentially applicable" to CO_2?

The April 10, 1998, Memorandum from Jonathan Cannon to Carol Browner states that CO_2 is an air pollutant and hence within the scope of EPA's authority to regulate. The Cannon Memorandum specifically noted that although EPA's regulatory authority extends to air pollutants, "[s]uch a general statement of authority is distinct from an EPA determination

that a particular air pollutant meets the specific criteria for EPA action under a particular provision of the Act." Section 108 of the CAA authorizes regulation of air pollutants if the criteria for regulation under that provision are met. EPA has not yet evaluated whether such criteria have been met for CO_2. Thus, at this time, we believe it is accurate to state that section 108 (and other CAA provisions authorizing regulation of air pollutants) are "potentially applicable" to CO_2.

11. CAA section 109(b) requires the Administrator to adopt NAAQS that are "requisite to protect" public heath and welfare. However, *unilateral* emissions reductions by the United States would have no measurable effect on global climate change. Therefore, it is not clear that the NAAQS program can have no application to the global warming issue, even theoretically, except in the context of an international regulatory regime, such as that proposed in the Kyoto protocol? Furthermore, since the CAA requires that NAAQS be "requisite" to protect public health and welfare, does this not imply that any NAAQS for CO_2 established outside the context of an international regulatory regime would be illegal?

The Clean Air Act does not dictate that EPA must be able to address all sources of a particular air pollution problem before it may address any of those sources. Rather, EPA may address some sources that "contribute" to a problem even if it cannot address all of the contributors. For example, EPA was not precluded from addressing airborne lead emissions because there are other sources of lead contamination, some of which may be beyond EPA's jurisdiction. *See Lead Industries Ass'n v. EPA, 647 F.2d 1130, 1136 (DC Cir. 1980), cert. denied Lead Industries Ass'n v. EPA, 449 U.S. 1042 (1980).* In this particular case, it is worth noting that the U.S. by itself contributes approximately 25% of today's worldwide emissions

of greenhouse gases. Just as noted above, section 109 of the CAA authorizes regulation of air pollutants if the criteria for regulation under that provision are met, and EPA has not evaluated whether such criteria have been met for CO_2.

12. In your answer to Q11 of our October 14th letter, you state that "EPA has not undertaken any estimate of the number of small-and mid-sized businesses and farms that emit 100 tons or more of CO_2 per year." We think EPA should undertake such an estimate. One study calculates that one million small-and mid-sized entities individually emit 100 tons of CO_2 per year and, thus, potentially could be regulated as "major stationary sources" under a CO_2 emissions control regime (Mark P. Mills, "a stunning Regulatory Burden: EPA Designating CO_2 as a Pollutant," Greening Earth Society, 1999). In any event, you note that 'some provisions of the Clean Air Act apply to "major stationary sources' and 'major emitting facilities,' but others do not." Please identify which provisions do or do not apply to such sources. Which, if any, of those provisions are also among those EPA consider "potentially applicable" to CO_2.

Parts C and D of Title I and Title V of the CAA specifically apply to "major stationary sources" and/or "major emitting facilities." These provisions of the CAA would apply to a source of an air pollutant only if EPA had regulated the pollutant pursuant to other provisions of the CAA (E.G., if it were a criteria pollutant under section 108). The terms "major stationary source" and "major emitting facilities" are also used in subpart II of Part C of Title I, which addresses visibility impairment, but EPA is not aware that CO_2 has ever been associated with visibility concerns.

13. In your response to Q13 of our October 14th letter, you state, "as noted above, and as we have repeatedly discussed

in correspondence with you, there are many regulatory

actions that have the effect, *or even the purpose,* of reducing greenhouse gases (sometimes including CO_2), but not the purpose of implementing the Kyoto Protocol" (emphasis added). Similarly, in Attachment M, dated February 18, 1999, you interpreted the Knollenberg funding limitation as follows: "EPA may expend funds to propose or issue a regulation for a number of purposes including the reduction of greenhouse gas emissions, so long as the expenditures are in implementation of existing law and not the purpose of implementing, or in preparation for implementing, the Kyoto Protocol." We disagree.

Reducing greenhouse gas emissions is the purpose of the Kyoto Protocol. There is no clear practical difference between issuing regulations to accomplish the purpose of the Kyoto Protocol and issuing regulations "for the purpose implementing" the Kyoto Protocol. Although we have raised this concern in previous correspondence, we feel it is necessary to do so again. If the Knollenberg limitation allows EPA to issue regulations *for the purpose* of reducing greenhouse gas emissions, does it not effectively allow EPA to implement the Kyoto Protocol, as long as EPA is careful not to mention the Protocol in the rulemaking?

Similarly, would it not have been pointless for the Senate to have insisted, in ratifying the Rio Treaty, that the Administration not commit the U.S. to binding emission reductions without the further advice and consent of the Senate, if it were already in EPA"s power to impose such reductions under existing authority?

Regarding your first question above, we believe that we have previously addressed substantially the same question in previous correspondence, including, our letter of September

17,1999, which responded to your letter of August 12, 1999; our letter of July 23, 1999, which responded to your letter of June 30, 1999; and our letter of June 23, 1999, which responded to your follow-up questions from the May 20, 1999 joint hearing before the Subcommittee on National Economic Growth, Natural Resources, and Regulatory Affairs and the Subcommittee on Energy Research, Development, Production and Regulation. As we have stated previously, we believe there is a clear and sound distinction between implementation of the Kyoto Protocol, and any other appropriate actions regarding greenhouse gases taken under exiting authorities for the purposes specified in the Clean Air Act or other applicable authorities.

With respect to your second question, the Senate insisted that the Executive Branch not commit the U.S. to a binding *international* legal obligation (i.e., a treaty obligation) without further advice and consent. The Senate's statement on this point has no bearing on the scope of existing domestic legal authority to address pollution problems as a matter of domestic policy, independent of any international legal obligations.

14. We are puzzled by your response to Q14 of our October 14th letter. You state that "EPA has not commenced, with respect to CO_2, the formal scientific review process that is set forth in sections 108 and 109 regarding the setting of a new NAAQS." Yet, you go on to state, "EPA believes ...that the science supporting international action on climate change is clear and compelling." It is difficult to reconcile these statements. Are we to understand EPA regards the science supporting international action on climate change as "clear and compelling," yet does not believe the science is strong enough to commence a "formal scientific review process" to determine the appropriateness of domestic regulatory action?

The use of EPA's legal authorities involves adherence to specified legal and technical procedural steps, as well as discretion as to when to initiate applying this additional authority. For example, before proposing a NAAQS, EPA must review the relevant scientific and technical information in order to develop the air quality criteria referenced in section 108. The Agency has not initiated this formal process regarding CO_2, nor does it currently have plans to do so. The status of this action does not undermine the Administrations's view concerning the compelling science demonstrating global climate change.

[from EPA administrative record]

[USEPA Symbol]

UNITED STATE ENVIRONMENTAL PROTECTION AGENCY

WASHINGTON D.C. 20460

[Date Stamped]

July 12, 2000

Office of
General Counsel

Honorable David M. McIntosh
Chairman, Subcommittee on National Economic Growth,
Natural Resources and Regulatory Affairs
Committee on Government Reform
U.S. House of Representatives
2157 Rayburn House Office Building
Washington, DC 20515-6143

Dear Mr. Chairman:

I am writing in response to your letter of May 10, 2000, regarding EPA's authority with respect to regulation of carbon dioxide (CO_2). Specifically, you requested my thoughts on the question of EPA's authority in light of the recent Supreme Court decision in Food and Drug Administration (FDA) v. Brown & Williamson (120 S.Ct. 1291, March 21, 2000). In that case, the Court found that FDA lacks authority to regulate tobacco products as customarily marketed under the provisions of the Food, Drug, and Cosmetic Act (FDCA). You suggest

that the Court's analysis in Brown & Williamson supports your view that EPA similarly lacks authority to regulate CO_2 under any provision of the Clean Air Act (CAA).

While I appreciate your interest in my thoughts on this matter and will endeavor to be of assistance, the hypothetical nature of the exercise makes it difficult to conduct the analysis you request. As this Administration has repeatedly assured you, EPA has no current plans to regulate CO_2. Nor is EPA currently conducting any studies or analyses to determine whether the criteria for regulation of CO_2 under any particular provision of the CAA would be met.[1] Nevertheless, I have attempted in the attachment to respond to your inquiry as fully as possible.

Please let me know if we can be of further assistance, or please have your staff contact Alexandra Teitz of my office at (202)564-5594.

Sincerely,

s/

Gary S. Guzy
General Counsel

Attachment

[1] While EPA is in receipt of a petition requesting that the Agency regulate emissions of several greenhouse gases, including CO_2, under section 202(a)(1) of the CAA, the Agency plans to solicit public comment on the petition prior to taking any other action.

Q1. In Food and Drug Administration (FDA) v. Brown & Williamson (120 S. Ct. 1291, March 21, 2000), the Supreme Court overturned FDA's regulation of tobacco products as exceeding the authority Congress had delegated to FDA. FDA argued as follows: The Federal Food, Drug, and Cosmetic Act (FDCA) authorized FDA to regulate "drugs" and "devices;" nicotine can be considered a "drug;" cigarettes and smokeless tobacco can be considered "devices" for delivering nicotine to the body; therefore, FDCA authorized FDA to regulate cigarettes and smokeless tobacco. The Environmental Protection Agency's (EPA's) argument with respect to carbon dioxide (CO_2) is strikingly similar. According to EPA, the Clean Air Act (CAA) authorizes EPA to regulate "air pollutants;" CAA section 103(g) lists CO_2 among several "air pollutants;" therefore, EPA may regulate CO_2.

In Brown & Williamson, the Court cautioned against agencies inferring grants of authority from the "definitional possibilities"of statutory language taken out of context. The Court stated: "In determining whether Congress has specifically addressed the question at issue, a reviewing court should not confine itself to examining a particular statutory provision in isolation. The meaning - or ambiguity - of certain words or phrases may only become evident when placed in context." The Court also cited Brown v. Gardner (513 U.S. 115, 118, 1994): "Ambiguity is a creature not of definitional possibilities but of statutory context" (Brown & Williamson, p. 1300-01). As I have noted in previous correspondence with you, the context for the CAA's sole mention of CO_2 -section 103(g) - is a non-regulatory provision. Moreover, that provision concludes with the admonition that "Nothing in this subsection [i.e., including the reference to CO_2 as an 'air pollutant'] shall be construed to authorize the imposition on any person of air

pollution control requirements." Additionally, in a October 5, 1999 letter to Chairman McIntosh, Congressman John Dingell explained: "While it [section 103(g) refers, as noted in the EPA memorandum, to carbon dioxide as a 'pollutant,' House and Senate conferees never agreed to designate carbon dioxide as a pollutant for regulatory purposes."

EPA's argument appears to suffer from the same flawed reliance on "definitional possibilities" that the Court found in FDA's claim of authority to regulate tobacco products. Do you agree? If not, please explain why you believe the Court's reasoning does not apply to EPA's attempt to use the words "air pollutants" and "carbon dioxide" in section 103(g) as a source of regulatory authority. Specifically, please identify the "statutory context" that explains and justified EPA's argument.

As a preliminary matter, I wish to clarify EPA's position regarding its legal authority to regulate CO_2 under the CAA. As I have stated in previous correspondence and as stated by my predecessor in the Memorandum from Jonathan Cannon to Carol Browner, April 12, 1998, EPA's legal authority to regulate CO_2 derives from the definition of "air pollutant" contained in section 302(g), in conjunction with the various provisions authorizing EPA to regulate air pollutants if the criteria specified in those provisions are met. As I have indicated in previous correspondence with you, the reference to CO_2 as an air pollutant in section 103(g) supports that authority. EPA has not asserted that section 103(g) itself provides regulatory authority.

You have raised the question of whether the Court's reasoning in Brown & Williamson could apply to EPA's assertion that it has authority under various provisions of the CAA to regulate CO_2 as an air pollutant if the Agency finds that

the specific criteria of a statutory provision are met. It appears that the Court's reasoning in this case arguably could be applied to the interpretation of any statutory provision that appears clear from the language of the provision but could be questioned based on other factors, such as the purpose of the statute as a whole, or Congressional intent in adopting that statute or other legislation. On the other hand, other cases focusing on the "plain language" of the statutory provision to be interpreted caution against overriding the statutory language based on other indications of Congressional intent.[2] The persuasiveness of the interpretive approach applied in any

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[2] See Consumer Product Safety Commission v. GTE Sylvania, 100 S.Ct. 2051, 2056 (1980) ("We begin with the familiar canon of statutory construction that the starting point for interpreting a statute is the language of the statute itself. Absent a clearly expressed legislative intention to the contrary, that language must ordinarily be regarded as conclusive."); U.S. v. Ron Pair Enterprises, 109 S.Ct. 1026, 1030 (1989) ("The task of resolving the dispute over the meaning of [a statutory provision] begins where all such inquiries must begin: with the language of the statute itself....In this case it is also where the inquiry should end, for where, as here, the statute's language is plain, 'the sole function of the courts is to enforce it according to its terms.'" (citations omitted)); U.S. v. Gonzales, 117 S.Ct. 1032, 1035 (1997) ("Given the straightforward statutory command, there is no reason to resort to legislative history" citing Connecticut Nat. Bank v. Germain, 112 S.Ct. 1146, 1149-1150); Shannon v. U.S., 114 S.Ct. 2419, 2426 (1994) ("[C]ourts have no authority to enforce [a] princip[e] gleaned solely from legislative history that has no statutory reference point." (cites omitted)); AFL-CIO v. Donovan, 757 F.2d 330, 344 (D.C. Cir. 1985) ("arguments as to the general intent or mind set of Congress cannot overturn the clear language of a specific provision."); Wisconsin Public Intervenor v. Mortier, 111 S.Ct. 2476, 2488 ("Their only mistake was failing to recognize how unreliable Committee Reports are-not only as a genuine indicator of congressional intent but as a safe predictor of judicial construction. We use them when it is convenient, and ignore them when it is not.") (Scalia, J., concurring in judgment). See also Shannon v. U.S. at 2426 ("Members of this Court have expressed differing views regarding the role that legislative history should play in statutory interpretation.")

particular case will obviously depend upon the specifics of the case at issue -- in particular the clarity of the statutory language, the fact pattern in which that language is being applied, and the strength of various other considerations such as indicators of contrary congressional intent.

As there is no specific EPA regulation, factual record, or even particular provision of the CAA at issue here, it is premature to attempt to evaluate these legal arguments as applied to EPA's hypothetical regulation of CO_2. At most , it seems useful to recognize that the Court in Brown & Williamson heavily emphasized the factual context of the case in terms of the legislative and administrative history of the issue of tobacco and public health. As I discuss below, that factual context is very different in key respects from the history of Congress'and EPA's actions to date regarding climate change and emissions of CO_2, which casts doubt on the relevance of the Brown & Williamson holding to the issue of EPA's authority to regulate CO_2 under the CAA.

In Brown & Williamson, the Court found that Congress had directly spoken to the issue of FDA's authority to regulate tobacco products as customarily marketed and had answered in the negative. See id. at 1301. The Court made this determination based on a couple of key factors. One factor was the court's identification of a particular regulatory outcome that it found would be mandated by the FDCA that also would be contrary to otherwise clearly expressed Congressional intent. The Court determined that in light of the inherent danger posed by use of tobacco products, as demonstrated by FDA's record, the FDCA mandated that if such products were covered by that statute, FDA must ban them. Yet this result would directly conflict with the Court's finding that Congress specifically intended to allow continued manufacture and use of tobacco products, as demonstrated through numerous pieces of

legislation in which Congress regulated tobacco without removing it from the market. See id. at 1302. The Court reasoned that because application of the FDCA to tobacco would produce a result contrary to "Congress' clear intent...[t]he inescapable conclusion is that there is no room for tobacco products within the FDCA's regulatory scheme." See id. At 1306.

The Court appeared particularly troubled in this case by the following contradiction: "If [tobacco products] cannot be used safely for any therapeutic purpose, and yet they cannot be banned, they simply do not fit [in the FDCA's regulatory scheme]." See id at1306.

Applying EPA's authority to regulate any air pollutant under the CAA, including CO_2, would not appear to raise any such inherent contradictions. Congress clearly intended through its initial adoption and subsequent reauthorizations of the CAA to provide APA broad general authority to address various threats to public health and the environment from air pollution. The purposes of the Clean Air Act -- "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population" -- do not appear to conflict with an exercise of EPA's authority to regulate a particular air pollutant if the Agency finds that the criteria of the relevant regulatory provision of the CAA are met. The question of whether the CAA authorizes a particular regulatory approach to CO_2 is, of course, dependent on the facts of the situation. None of those provisions, however, would appear to necessitate a ban on CO_2 emissions.

The Brown & Williamson Court also based its conclusion on Congress' actions on other legislation, especially in light of FDA's position that it had no authority in this area. The Court explains that FDA believed it had no authority to regulate

tobacco as customarily marketed, Congress understood and acted on that belief by regulating tobacco itself, and Congress' regulatory scheme excluded FDA and other administrative agencies from exercising policy in this area. See id. at 1312-13. "Congress has enacted several statutes addressing the particular subject of tobacco and health, creating a distinct regulatory scheme for cigarettes and smokeless tobacco." Id. "It has also enacted this legislation against the background of the FDA repeatedly and consistently asserting that it lacks jurisdiction under the FDCA to regulate tobacco products as customarily marketed. Further, Congress has persistently acted to preclude a meaningful role for any administrative agency in making policy on the subject of tobacco and health. Moreover, the substance of Congress' regulatory scheme is, in an important respect, incompatible with FDA jurisdiction." Id. at 1313. Thus, "Congress' tobacco-specific statutes have effectively ratified the FDA's long-held position that it lacks jurisdiction under the FDCA to regulate tobacco products. Congress has created a distinct regulatory scheme to address the problem of tobacco and health, and that scheme, as presently constructed, precludes any role for the FDA." Id. at 1307.

This set of circumstances is simply not repeated regarding the regulation of CO_2. EPA has never asserted that it lacks authority to regulate emissions of greenhouse gases, much less repeatedly disavowed such authority over a thirty year period. Congress has not established any broad-based requirements specifically to address climate change, much less created a distinct alternative regulatory scheme for emissions of CO_2. Nor has Congress acted to preclude administrative agencies from making policy on the topic of climate change. To the contrary, with Congressional authorization and appropriations, EPA has been working intensively on climate change issues for many years now, in areas such as international negotiations,

policy evaluation, scientific and economic research, and establishing voluntary programs to reduce greenhouse gas emissions, the latter as part of the 1993 President's Climate Change Action Plan and 1999 Climate Change Technology Initiative.

For these reasons, I believe both that it is premature to attempt to apply the Court's reasoning in Brown & Williamson to the question of EPA's authority to regulate CO_2 under the CAA and that the case is unlikely to be particularly illuminating, given the apparent absence of comparable factual circumstances.

Q2. In the Brown v. Williamson case, the Court noted that: "It is a 'fundamental canon of statutory construction that the words of a statute must be read in their context and with a view to their place in the overall statutory scheme." In addition, the Court stated that "A court must therefore interpret the statute 'as a symmetrical and coherent regulatory scheme,' and 'fit, if possible, all parts in to a harmonious whole'" Brown & Williamson, p. 1301, internal citations omitted). These words are telling, because the CAA contains no "overall statutory scheme" with respect to greenhouse gases or global warming. Furthermore, as noted in previous correspondence, CO_2 does not fit harmoniously in any regulatory provision of the CAA. For example, regulating CO_2 under the national ambient air quality standards (NAAQS) program would be an attempt to address a global phenomenon of the troposphere (the greenhouse effect) through a regulatory structure designed to address local or regional conditions of the ambient air. Similarly, regulating CO_2 under the hazardous air pollutant (HAP) program would be an attempt to control a benign substance as though it were a toxic substance. In short, EPA regulation of CO_2 under the CAA would create

***incoherent* and *asymmetrical* regulatory schemes. Do you agree? If not, please explain how the NAAQS or HAPs program might be stretched to include CO_2 without incoherence, disharmony, or asymmetry.**

As our previous correspondence addressed substantially the same question posed here please see our response of February 16, 2000 to your letter of December 10, 1999, and our response of December 1, 1999 to your letter of October 14, 1999.

Q. 3. The Court in Brown & Williamson partly based its decision on legislative history. It states, "In fact, on several occasions...Congress considered and rejected bills that would have granted FDA such jurisdiction" [i.e., authority to regulate tobacco products] (Brown & Williamson, p. 1307). The Court also noted that "the meaning of one statute may be affected by other Acts, particularly where Congress has spoken subsequently and more specifically to the topic at hand" (Brown & Williamson, p. 1301). Likewise, Congress considered and rejected greenhouse gas regulation when it enacted the 1990 CAA Amendments. Congress subsequently and more specifically rejected regulatory approaches to addressing global climate change and emissions of greenhouse gases when it enacted the omnibus Energy Policy Act of 1992. Do you agree that Congressional rejection of legislation to grant EPA authority to regulate CO_2 supports the conclusion that EPA currently lacks such authority? If EPA does not agree, please explain why.

The Court in Brown & Williamson based its decision partly on legislative history showing that FDA had disavowed FDCA authority over tobacco as customarily marketed for 35 years and that Congress had affirmatively adopted other schemes to address tobacco over the same period. See id. at

1312. However, the Court explicitly *disavows* as a basis for its decision Congress' rejection of legislation that would have explicitly give FDA authority to regulate tobacco as customarily marketed. See id. at 1312. "We do not rely on Congress' failure to act-its consideration and rejection of bills that would have given the FDA this authority-in reaching [the] conclusion [that the 'actions by Congress over the past 35 years preclude an interpretation of the FDCA that grants the FDA jurisdiction to regulate tobacco products.']" Id. at 1312. As the dissent notes, case law provides that "failed requests do not prove agency 'did not already possess' authority." See id. at 1326 (citation omitted). The Court instead focuses on Congress' affirmative actions in enacting several statutes "creating a distinct regulatory scheme for cigarettes and smokeless tobacco." Thus, the Brown & Williamson decision does not undermine, and arguably implicitly supports, the view that failure to enact a statutory provision specifically directed at climate change has no effect on general CAA provisions authorizing EPA to identify and regulate any air pollutants meeting the statutory criteria relating to endangerment of health or welfare.

Q4. In Brown & Williamson, the Court partly based its decision on the common sense of the matter. It stated that courts "must be guided to a degree by common sense as to the manner in which Congress is likely to delegate a policy decision of such economic and political magnitude to an administrative agency" (Brown & Williamson, p. 1301). Moreover, the Court explained that unlike an implicit delegation from Congress to fill in minor statutory gaps, "it is highly unlikely that Congress would leave the determination of whether an industry will be entirely, or even substantially, [regulated] to agency discretion") Brown & Williamson, p. 1315, internal citation omitted). This analysis applies with even more force to a regulatory

global warming mitigation program. Whereas tobacco regulation would primarily affect just one industry, CO_2 regulation would directly affect whole economic sectors, including energy production, transportation, manufacturing, and agriculture. Do you agree that establishing a regulatory global warming mitigation program involves a policy decision of at least the "economic and political magnitude" as the regulation of tobacco products, and, therefore, it is highly unlikely Congress would leave the determination of whether CO_2 will be regulated to EPA's discretion? If EPA does not agree, please explain why.

Again, it is difficult to analyze this question in the abstract. The argument reflected in the question depends on the assumption that any regulation of CO_2 would necessarily have great "economic and political magnitude." At this stage, it is not possible to determine whether the magnitude of consequences from regulation of CO_2 would be greater or less than those related to the regulation of other pollutants over which EPA's authority is unquestioned.

Q5. Do you agree that the Supreme Court's reasoning in Brown & Williamson makes it less likely that the courts would uphold an attempt by EPA to regulate CO_2? If EPA does not agree, please explain why.

Please see my response to Question 1 discussing the applicability of the Brown & Williamson analysis to the question of EPA's authority to regulate CO_2.

[from EPA administrative record]

August 28, 2003

MEMORANDUM

SUBJECT: EPA's Authority to Impose Mandatory Controls to Address Global Climate Change under the Clean Air Act

FROM: Robert E. Fabricant
General Counsel

TO: Marianne L. Horinko
Acting Administrator

I. Introduction and Background

EPA was petitioned by the International Center for Technology Assessment (ICTA) and a number of other organizations to regulate motor vehicle emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs) under the Clean Air Act (CAA or Act). Relevant to the Agency's consideration of this petition is an April 10, 1998 memorandum regarding "EPA's Authority to Regulate Pollutants Emitted by Electric Power Generation Sources" from then- General Counsel Jonathan Z. Cannon to then-Administrator Carol M. Browner. In that memorandum, Mr. Cannon concludes that CO_2 is an "air pollutant" under the CAA and thus subject to regulation under the CAA to the extent the criteria of any of the Act's regulatory provisions are met.

I have reviewed Mr. Cannon's memorandum and the text and history of the CAA in the context of other congressional actions specifically addressing global climate change. Based on my review, I have determined that the CAA does not authorize

EPA to regulate for global climate change purposes. Accordingly, CO_2 and other GHGs cannot be considered "air pollutants" subject to the CAA's regulatory provisions for any contribution anthropogenic GHG emissions may make to global climate change. This memorandum explains the reasons for my conclusions and formally withdraws Mr. Cannon's April 10, 1998 memorandum as no longer representing the views of EPA's General Counsel.[1] The legal positions set forth in this memorandum apply for purposes of deciding the ICTA petition and for all other relevant regulatory purposes under the CAA.

II. The Cannon Memorandum

Mr. Cannon's memorandum (Cannon memorandum) was prepared in response to a request from Congressman DeLay to Administrator Browner. At a Fiscal Year 1999 House Appropriations Committee hearing, Congressman DeLay questioned the Administrator about an EPA document stating, in part, that EPA currently has authority under the CAA to establish control requirements for emissions of nitrogen oxides, sulfur dioxide, CO_2 and mercury from electric power generation. He asked Administrator Browner whether she agreed with the statement, and in particular, whether she thought the CAA allows EPA to regulate emissions of CO_2. Administrator Browner agreed with the statement that the CAA grants EPA broad authority to address certain emissions, including those listed, and agreed to Congressman DeLay's request for a legal opinion on that point. The Cannon memorandum was prepared in response to that request.

The Cannon memorandum states that the CAA "provides that EPA may regulate a substance if it is (a) an 'air pollutant,'

[1] Gary S. Guzy, EPA's General Counsel following Mr. Cannon, also addressed EPA's authority to regulate CO_2. This memorandum will review and address his statements as well.

and (b) the Administrator makes certain findings regarding such pollutant (usually related to danger to public health, welfare, or the environment) under one or more of the Act's regulatory provisions." The memorandum further states that the CAA section 302(g) definition of "air pollutant" is "broad" and expressly "includes any physical, chemical, biological, or radioactive substance or matter that is emitted into or otherwise enters the ambient air." The memorandum notes that a substance can be an air pollutant even though it is naturally present in the air in some quantities, and that many pollutants already regulated by EPA are emitted from natural as well as anthropogenic sources (e.g., sulfur dioxide, particulate matter, and volatile organic compounds). It then concludes that emissions of nitrogen oxides, sulfur dioxide, CO_2, and mercury from electric power generation "are each a 'physical [and] chemical . . . substance which is emitted into . . . the ambient air,' and hence, . . . each is an air pollutant within the meaning of the Clean Air Act" (quoting from a portion of the statutory definition of air pollutant). As further support for its conclusion, the memorandum cites CAA section 103(g), which refers to CO_2 along with a number of substances already regulated as "air pollutants."

Turning to EPA's authority under the CAA, the Cannon memorandum states that "EPA's regulatory authority extends to air pollutants, which, as discussed above, are defined broadly under the Act . . ." The memorandum notes, however, that "a general statement of authority is distinct from an EPA determination that a particular air pollutant meets the specific criteria for EPA action under a particular provision of the Act." According to the memorandum, several CAA provisions potentially applicable to the four emissions of concern from utilities require "a determination by the Administrator regarding the air pollutants' actual or potential harmful effects on public health, welfare or the environment." The

memorandum explains that EPA already regulates nitrogen oxides, sulfur dioxide and mercury based on determinations by EPA or Congress that those substances have negative effects on public health, welfare, or the environment. With respect to CO_2, the memorandum states that "[w]hile CO_2 emissions are within the scope of EPA's authority to regulate, the Administrator has made no determination to date to exercise that authority under the specific criteria provided under any provision of the Act."

III. Other Previous EPA General Counsel Statements

Gary S. Guzy succeeded Mr. Cannon as EPA's General Counsel and also addressed the issue of whether EPA may regulate CO_2 under the CAA. In congressional testimony and subsequent correspondence, Mr. Guzy agreed with his predecessor's conclusion that the CAA definition of "air pollutant" is broad and encompasses CO_2 even though it has natural as well as man-made sources.[2]

Mr. Guzy also agreed that CO_2 may be regulated under the CAA to the extent the criteria of any of the Act's regulatory provisions are met. In Mr. Guzy's view, "[g]iven the clarity of the statutory provisions defining 'air pollutant' and providing authority to regulate air pollutants, there is no statutory ambiguity"[3] regarding whether EPA may regulate CO_2 under the CAA. He also stated that the absence of a CAA provision

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[2] Mr. Guzy testified before the Subcommittee on National Economic Growth, Natural Resources and Regulatory Affairs of the Committee on Government Reform, and the House Subcommittee on Energy and the Environment of the House Committee on Science on Oct. 6, 1999, and he responded to correspondence from one or both subcommittees on December 1, 1999, February 16, 2000, and July 11, 2000.

[3] Letter to the Subcommittee on National Economic Growth, Natural Resources and Regulatory Affairs of the Committee on Government Reform, and the House Subcommittee on Energy and the Environment of the House Committee on Science, December 1, 1999.

explicitly authorizing regulation to address climate change does not mean that EPA cannot regulate CO_2 under CAA provisions authorizing regulation of air pollutants generally, provided the applicable criteria for regulation are met: "Explicit mention of a pollutant in a statutory provision is not a necessary prerequisite to regulation under many CAA statutory provisions."[4] At the same time, Mr. Guzy, like his predecessor, observed that EPA had not made any determinations under the specific provisions of the CAA to regulate CO_2.[5]

IV. Clean Air Act Authority to Address Global Climate Change

As part of the Agency's consideration of the ICTA petition and related public comments, I have reviewed the Cannon memorandum and Guzy statements regarding whether CO_2 is an "air pollutant" under the CAA and whether the CAA authorizes CO_2 regulation.[6] I have considered the statutory definition of "air pollutant" and whether CO_2 and other GHGs, as such, fall within that definition. I have also considered the broader issue of whether the CAA's general regulatory authorities are available to address global climate change in view of the unusually large economic and societal significance such regulation may have. Based on the analysis set forth below, I have concluded that the CAA does not authorize EPA to regulate GHGs to address global climate change. Although the Act specifically authorizes information development and "non-regulatory" measures related to global climate change,

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[4] Id.

[5] Id.; Mr. Guzy's Oct. 6, 1999 testimony, supra note 3.

[6] This memorandum uses the term "regulation" to refer to legally binding requirements promulgated by an agency under statutory authority. It does not include voluntary measures that emission sources may or may not undertake at their discretion.

there is no indication that Congress intended EPA to regulate in this particular area. Indeed, as a matter of statutory structure, the CAA is conspicuously missing a functional regulatory regime for addressing global climate change such as exists for addressing another global atmospheric issue, stratospheric ozone depletion. In light of the Supreme Court's decision in *Food and Drug Administration v. Brown & Williamson Tobacco Corp.,* 120 S.Ct 1291 (2000) (*Brown & Williamson*), it is clear that an administrative agency properly awaits congressional direction on a fundamental policy issue such as global climate change, instead of searching for new authority in an existing statute that was not designed or enacted to deal with that issue.

Issued before *Brown & Williamson* was decided, the Cannon memorandum assumed that if CO_2 were an "air pollutant" under the CAA, EPA would have authority to regulate it under the CAA to the extent the Act's criteria for regulation were met. That assumption was based on the fact that various CAA provisions authorize regulation of any "air pollutant" if the Administrator finds, among other things, that the pollutant causes or contributes to air pollution that may reasonably be anticipated to endanger "public health or welfare" or the environment. CAA section 302(h) specifies that the statute's references to "welfare" include "effects on . . . climate." The Cannon memorandum concluded that the CAA's broad definitions confer commensurately broad regulatory authority, without considering the potential significance of the policy issues raised or any contrary indications of congressional intent.

Brown & Williamson has made clear the need for a more thorough inquiry, particularly where unusually significant policy questions are involved. Accordingly, I have examined the fundamental issue of whether the CAA authorizes

regulation for global climate change purposes. As instructed by the Supreme Court's opinion in *Brown & Williamson*, I have reviewed the CAA's facially broad grants of authority in the context of the statute's purpose, structure and history and other relevant congressional actions to determine whether such grants reach the global climate change issue. Based on my review, I have concluded that the CAA does not authorize regulation to address global climate change.

Three codified and uncodified provisions of the CAA expressly touch on matters related to global climate change. Specifically, uncodified section 821 of the CAA Amendments of 1990 requires measurement of CO_2 emissions from utilities subject to permitting under Title V of the Act. CAA section 602 directs EPA to determine the "global warming potential" of substances that deplete stratospheric ozone. CAA section 103(g) calls on EPA to develop "nonregulatory" measures for the prevention of multiple "air pollutants" and lists several air pollutants and CO_2 for that purpose. None of these provisions authorizes regulation, and two of them expressly preclude their use for authorizing regulation (CAA sections 103(g) and 602).

All three provisions were enacted in 1990, when the CAA was last comprehensively amended. By that time, global climate change had become a prominent national and international issue. During the 1980s, scientific discussions about the possibility of global climate change led to growing public concern both in the U.S. and abroad. In response, the U.S. and other nations developed the United Nations Framework Convention on Climate Change (UNFCCC). President George H. W. Bush signed, and the U.S. Senate approved, the UNFCCC in 1992, and the UNFCCC took effect in 1994.

The UNFCCC established the "ultimate objective" of "stabiliz[ing] greenhouse gas concentrations in the atmosphere

at a level that would prevent dangerous anthropogenic interference with the climate system" (Article 2 of the UNFCCC). All parties to the UNFCCC agreed on the need for further research to determine the level at which GHG concentrations should be stabilized, acknowledging that "there are many uncertainties in predictions of climate change, particularly with regard to the timing, magnitude and regional patterns thereof"(findings section of UNFCCC).

A central issue for the UNFCCC – whether binding emission limitations should be set – was also considered in the context of amending the CAA. A Senate committee included in its CAA amendment bill a provision requiring EPA to set CO_2 emission standards for motor vehicles. However, that provision was removed from the bill on which the full Senate voted, and the bill eventually enacted was silent with regard to motor vehicle CO_2 emission standards. Instead, Congress enacted the three provisions described above, calling on EPA to conduct research and collect information related to global climate change and develop "nonregulatory" strategies for reducing CO_2 emissions.

Only the research and development provision of the CAA – section 103 – specifically mentions CO_2, and the legislative history of that section indicates Congress was focused on seeking a sound scientific basis on which to make future decisions on global climate change. Representatives Roe and Smith, two of the principal authors of section 103 as amended, explained that EPA's "science mandate" needed updating to deal with new, more complex issues, including "global warming." Committee on Environment and Public Works, U.S. Senate, *A Legislative History of the Clean Air Act Amendments of 1990*, S. Rep. 103-38, Vol. II at 2776 and 2778 (1993). They expressed concern that EPA's research budget had been too heavily focused on supporting existing regulatory actions when

the Agency also needed to conduct long-term research to "enhance EPA's ability to predict the need for future action." Id. at 2777.

In providing EPA with expanded research and development authority, Congress did not provide commensurate regulatory authority. In section 103(g), Congress directed EPA to establish a "basic engineering research and technology program to develop, evaluate and demonstrate" strategies and technologies related to air emissions and specifically called for improvements in such measures for preventing CO_2 as well as several specified air pollutants. But it expressly provided that nothing in the subsection "shall be construed to authorize the imposition on any person of air pollution control requirements." As if to drive home the point, section 103(g) was revised in conference to include the term "nonregulatory" to describe the "strategies and technologies" the subsection was intended to promote, and this point was underscored in the conference report. H.R. Conf. Rep. No. 101-952 at 349 (1990). In its treatment of the global climate change issue in the CAA amendments, Congress made clear that it awaited further information before making decisions on the need for regulation.

Beyond Congress' specific CAA references to CO_2 and global warming, another aspect of the Act cautions against construing its provisions to authorize regulation to address global climate change. The CAA provisions addressing stratospheric ozone depletion demonstrate that Congress has understood the need for specially tailored solutions to global atmospheric issues, and has expressly granted regulatory authority when it has concluded that controls may be needed as part of those solutions. The causes and effects of stratospheric ozone depletion are global in nature. Anthropogenic substances that deplete stratospheric ozone are emitted around the world and are very long-lived; their depleting effects and the

consequences of those effects occur on a global scale. In the CAA prior to its amendment in 1990, Congress specifically addressed the problem in a separate portion of the statute (part B of title I) that recognized the global nature of the issue and called for negotiation of international agreements to ensure world-wide participation in research and any control of stratospheric ozone-depleting substances. In the 1990 CAA amendments, Congress again addressed the issue in a discrete portion of the statute (title VI) that similarly provides for coordination with the international community. Moreover, both incarnations of the CAA's stratospheric ozone provisions contain express authorization for EPA to regulate as scientific information warrants. In light of this CAA treatment of stratospheric ozone depletion, it would be anomalous to conclude that Congress intended EPA to address global climate change under the CAA's general regulatory provisions, with no provision recognizing the international dimension of the issue and any solution, and no express authorization to regulate.

EPA's prior use of the CAA's general regulatory provisions provides an important context. Since the inception of the Act, EPA has used these provisions to address air pollution problems that occur primarily at ground level or near the surface of the earth. For example, national ambient air quality standards (NAAQS) established under CAA section 109 address concentrations of substances in the ambient air, and the related public health and welfare problems. This has meant setting NAAQS for concentrations of ozone, carbon monoxide, particulate matter and other substances in the air near the surface of the earth, not higher in the atmosphere. Cf. *Hancock v. Train*, 426 U.S. 167, 169 n. 4 (1976) (noting in a general discussion of the NAAQS provisions of the CAA that EPA has "defined[d] 'ambient air' as 'that portion of the atmosphere, external to buildings, to which the general public has access,'" citing 40 C.F.R. section 50.1(e) (emphasis added), which is still

in effect). Concentrations of these substances generally vary from place to place as a result of differences in local or regional emissions and other factors (e.g., topography), although long range transport also contributes to local concentrations in some cases. By contrast, CO_2 is fairly consistent in concentration throughout the *world's* atmosphere up to approximately the lower stratosphere. Atmospheric concentrations of CO_2 are much more like the kind of global phenomenon Congress addressed through adoption of the specific provisions of Title VI.

In assessing the availability of CAA authority to address global climate change, it is also useful to consider whether the NAAQS system – a key CAA regulatory mechanism – could be used to effectively address the issue. As discussed in the Agency's decision on the ICTA petition being issued concurrently with this memorandum, unique and basic aspects of the presence of key GHGs in the atmosphere make the NAAQS system fundamentally ill-suited to addressing global climate change. Many GHGs reside in the earth's atmosphere for very long periods of time. CO_2 in particular has a residence time of roughly 50-200 years. This long lifetime along with atmospheric dynamics means that CO_2 is well mixed throughout the atmosphere, up to approximately the lower stratosphere. The result is a vast global atmospheric pool of CO_2 that is fairly consistent in concentration everywhere along the surface of the earth and vertically throughout this area of mixing.

While atmospheric concentrations of CO_2 are fairly consistent globally, the potential for either adverse or beneficial effects in the U.S. from these concentrations depends on complicated interactions of many variables on the land, in the oceans, and in the atmosphere, occurring around the world and over long periods of time. Characterization and assessment of such effects and the relation of such effects to atmospheric

concentration of CO_2 in the U.S. would present scientific issues of unprecedented complexity in the NAAQS context. The long-lived nature of the CO_2 global pool would also make it extremely difficult to evaluate the extent over time to which effects in the U.S. would be related to anthropogenic emissions in the U.S. Finally, the nature of the global pool would mean that any CO_2 standard that might be established would in effect be a worldwide ambient air quality standard, not a national standard – the entire world would be either in compliance or out of compliance.

Such a situation would be inconsistent with a basic underlying premise of the CAA regime for implementation of a NAAQS - that actions taken by individual states and by EPA can generally bring all areas of the U.S. into attainment of a NAAQS. The statutory NAAQS implementation regime is fundamentally inadequate when it comes to a substance like CO_2, which is emitted globally and has relatively homogenous concentrations around the world. A NAAQS for CO_2, unlike any pollutant for which a NAAQS has been established, could not be attained by any area of the U.S. until such a standard were attained by the entire world as a result of emission controls implemented in countries around the world. The limited flexibility provided in the Act to address the impacts of foreign pollution transported to the U.S. was not designed to address the challenges presented by long-lived global atmospheric pools such as exist for CO_2. The globally pervasive nature of CO_2 emissions and atmospheric concentrations presents a unique problem that fundamentally differs from the kind of environmental problem that the NAAQS system was intended to address and is capable of solving.

Other congressional actions confirm that Congress did not authorize regulation under the CAA to address global climate change. Starting in 1978, Congress passed several pieces of

legislation specifically addressing global climate change. With the National Climate Program Act of 1978, 15 U.S.C. 2901 et seq., Congress established a "national climate program" to improve understanding of "climate processes, natural and man induced, and the social, economic, and political implications of climate change" through research, data collection, assessments, information dissemination, and international cooperation. In the Global Climate Protection Act of 1987, 22 U.S.C. 2651 note, Congress directed the Secretary of State to coordinate U.S. negotiations concerning climate change, and EPA to develop and propose to Congress a coordinated national policy on the issue. Three years later, Congress passed the Global Change Research Act of 1990, 15 U.S.C. 2931 et seq., establishing a Committee on Earth and Environmental Sciences to coordinate a 10-year research program. That statute was enacted one day after the CAA Amendments of 1990 was signed into law. Also in 1990, Congress passed Title XXIV of the Food and Agriculture Act, creating a Global Climate Change Program to research global climate agricultural issues (section 2401 of Pub.L. No. 101-624).

With these statutes Congress sought to develop a foundation for considering whether future legislative action was warranted and, if so, what that action should be. From federal agencies, it sought recommendations for national policy and further advances in scientific understanding and possible technological responses. It did not, however, authorize any federal agency to take any regulatory action in response to those recommendations and advances. In fact, Congress declined to adopt other legislative proposals, contemporaneous with the bills to amend the CAA in 1989 and 1990, to require GHG emissions reductions from stationary and mobile sources (see, e.g., S. 1224, 101st Cong. (1989); H.R. 5966, 101st Cong.

(1990)).[7] While Congress did not expressly preclude agencies from taking regulatory action under other statutes, its actions strongly indicate that when Congress was amending the CAA in 1990, it was awaiting further information before deciding *itself* whether regulation to address global climate change is warranted and, if so, what form it should take.

Since 1990, Congress has taken other actions consistent with the view that Congress did not authorize CAA regulation for global climate change purposes. In the 1992 Energy Policy Act, Congress called on the Secretary of Energy to assess various GHG control options and report back to Congress, and to establish a registry for reporting voluntary GHG reductions. Following ratification of the UNFCCC, nations party to the Convention negotiated the Kyoto Protocol calling for mandatory reductions in developed nations' GHG emissions. While the Kyoto Protocol was being negotiated, the Senate in 1997 adopted by a 95-0 vote the Byrd-Hagel Resolution, which stated that the U.S. should not be a signatory to any protocol that would result in serious harm to the economy of the U.S. or that would mandate new commitments to limit or reduce U.S. GHG emissions unless the Protocol also mandated new, specific, scheduled commitments to limit or reduce GHG emissions for developing countries within the same compliance period. Although the Clinton Administration signed the Kyoto Protocol, it did not submit it to the Senate for ratification out of concern that the Senate would reject the treaty. Congress also attached language to appropriations bills that until recently barred EPA from implementing the Kyoto Protocol without Senate ratification (see, e.g., the Knollenberg amendments to

[7] The fact that many of these bills were considered in the context of national energy policy, not air pollution policy, is further illustration that Congress did not consider the CAA a vehicle for global climate change regulation. See, e.g., S. 324, 101st Cong. (1989); H.R. 5521, 101st Cong. (1990).

FY 1999 and 2000 VA-HUD and Independent Agencies Appropriations Acts).[8] Since enactment of the 1990 CAA amendments, numerous bills to control GHGs emissions from mobile and stationary sources have failed to win passage (see, e.g., H.R. 2663, 102d Cong., 1st Sess. 137 *Cong. Rec.* H4611 (daily ed. 1991)).

As noted above, the Supreme Court has ruled that facially broad grants of authority must be interpreted in the context of the statute's purpose, structure and history and other relevant congressional actions. In *Brown & Williamson*, the Court reviewed an FDA assertion of authority to regulate tobacco products under the Food, Drug and Cosmetic Act (FDCA). That statute contains a broadly worded grant of authority for FDA to regulate "drugs" and "devices," terms which the statute also broadly defines. However, the FDCA does not specifically address tobacco products while other federal laws expressly govern the marketing of those products.

Notwithstanding the FDCA's facially broad grant of authority, the Supreme Court explained that "[i]n extraordinary cases, . . . there may be reason to hesitate before concluding that Congress has intended such an implicit delegation." *Brown & Williamson*, 120 S.Ct. at 1314. The Court noted that FDA was "assert[ing] jurisdiction to regulate an industry constituting a significant portion of the American economy," despite the fact that "tobacco has its own unique political history" that had led Congress to create a distinct regulatory scheme for tobacco products. Id. at 1315. The Court concluded that FDA's assertion of authority to regulate tobacco was "hardly an ordinary case. " Id. The Court analyzed FDA's authority in light of the language, structure and history of the FDCA and

[8] Since the President has made clear that the U.S. will not become a party to the Kyoto Protocol, there has been no continuing need for that restriction.

other federal legislation and congressional action specifically addressing tobacco regulation, including failed legislative attempts to confer authority of the type FDA was asserting. Based on that analysis, the Court determined that Congress did not "intend[] to delegate a decision of such economic and political significance . . . in so cryptic a fashion." Id.

As discussed in the Agency's response to the ICTA petition, regulation to address global climate change would have even greater potential significance than the regulation of tobacco under FDCA. By far the most abundant anthropogenic GHG is CO_2, which is emitted whenever fossil fuels such as coal, oil, and natural gas are used to produce energy. The production and use of fossil fuel-based energy undergirds almost every aspect of the nation's economy. For example, approximately 75 percent of the electric power used in the U.S. is generated from fossil fuel, and the country's transportation sector is almost entirely dependent on oil. To the extent significant reductions in U.S. CO_2 emissions were mandated by EPA, power generation and transportation would have to undergo widespread and wholesale transformations, affecting every sector of the nation's economy and threatening its overall economic health.

In view of the unusually profound implications of global climate change regulation, it is unreasonable to believe that Congress intended "to delegate a decision of such . . . significance . . . in so cryptic a fashion." Id. An administrative agency properly awaits congressional direction before addressing a fundamental policy issue such as global climate change, instead of searching for authority in an existing statute that was not designed or enacted to deal with the issue. I therefore conclude the CAA does not authorize regulation to address global climate change.

Because the CAA does not authorize regulation to address climate change, it follows that CO_2 and other GHGs, as such, are not air pollutants under the CAA's regulatory provisions, including sections 108, 109, 111, 112 and 202. CAA authorization to regulate is generally based on a finding that an air pollutant causes or contributes to air pollution that may reasonably be anticipated to endanger public health or welfare. CAA section 302(g) defines "air pollutant" as "any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive . . . substance or matter which is emitted into or otherwise enters the ambient air. Such term includes any precursors to the formation of any air pollutant[.]" The root of the definition indicates that for a substance to be an "air pollutant," it must be an "agent" of "air pollution." Because EPA lacks CAA regulatory authority to address global climate change, the term "air pollution" as used in the regulatory provisions cannot be interpreted to encompass global climate change. Thus, CO_2 and other GHGs are not "agents" of air pollution and do not satisfy the CAA section 302(g) definition of "air pollutant" for purposes of those provisions.[9]

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[9] In this opinion, I do not reach all of the possible legal grounds suggested in public comments on the petition for concluding that EPA may not issue regulations to address global climate change under the CAA. For example, I do not address whether the GHGs named in the petition are "air pollution agent[s] or combination of such agents" under CAA section 302(g) for regulatory purposes were they subject to regulation under the Act for global climate change purposes. As described previously, the Cannon memorandum interpreted "air pollutant" to mean "any physical, chemical, biological, radioactive . . . substance or matter which is emitted into or otherwise enters ambient air" – in other words, virtually anything entering the ambient air regardless of whether it pollutes the air. In arriving at this interpretation, the Cannon memorandum failed to address, and effectively read out, the "air pollution agent" language at the core of the definition, thereby ignoring traditional rules of statutory construction. The CAA's legislative history (continued...)

The Cannon memorandum and the statements of Mr. Guzy concerning the status of CO_2 as an air pollutant are withdrawn as inconsistent with the interpretation that the CAA does not confer regulatory authority to address global climate change.

Even though the CAA does not authorize regulation to address global climate change, the potential contribution of anthropogenic GHG emissions to global climate change is still properly the subject of research and other nonregulatory activities under the CAA. In particular, EPA may continue to develop, evaluate, and demonstrate nonregulatory strategies and technologies for preventing CO_2 and other GHG emissions under section 103(g). EPA's efforts in this regard answer Congress' consistent call for advances in our understanding of the global climate change issue.

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[9] (...continued)
confirms that "air pollution agent" is integral to the meaning of "air pollutant." The original definition of "air pollutant," added in 1977, included only the core of the definition in effect today – "any air pollutant agent or combination of such agents." In 1977 when Congress sought to address air pollution stemming from radioactive materials, the phrase "including any physical, chemical, biological, radioactive . . . substance or matter which is emitted into or otherwise enters ambient air" was added to the definition. While Congress did not explain the addition, its context made its purpose clear – to establish that virtually any type of substance, including radioactive substances, *could be* an air pollution agent. If Congress had instead intended to establish that an air pollutant is any physical, biological, chemical or radioactive substance entering the air, however, it presumably would have dropped the "agent" language from the definition as moot. Similarly, a sentence added in 1990 concerning precursors would have been unnecessary had the definition already encompassed everything physical, chemical, biological or radioactive that enters the air. Thus, if global climate change were a form of "air pollution" for purposes of the CAA's regulatory provisions, CO_2 and other GHGs would still have to qualify as "air pollution agents" for them to be "air pollutants" for regulatory purposes.

As the discussion above makes clear, lack of authority under the CAA to impose regulation to address global climate change does not leave the federal government powerless to address the issue. The CAA and other federal statutes provide the federal government with ample authority to conduct the research necessary to better understand the nature, extent and effects of any human-induced global climate change and to develop technologies and nonregulatory strategies that will help achieve GHG emission reductions to the extent they prove necessary. Congress, of course, may decide that further efforts are necessary and pass specific legislation to that effect.

V. Conclusion

Based on the analysis above, I conclude that the CAA does not authorize regulation to address global climate change. In view of consistent congressional action to learn more about global climate change, the absence of express authority to regulate global climate change, no indication of congressional intent to provide such authority, and the far-reaching implications of regulation to address global climate change, I believe EPA cannot assert jurisdiction to regulate in this area. The Cannon memorandum and the statements by Mr. Guzy concerning this matter no longer represent the views of EPA's General Counsel.

cc: Jeffrey R. Holmstead, Assistant Administrator for Air and Radiation

[from EPA administrative record]

CLIMATE CHANGE SCIENCE

AN ANALYSIS OF SOME KEY QUESTIONS

Committee on the Science of Climate Change
Division on Earth and Life Studies
National Research Council

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Foreword

This study originated from a White House request to help inform the Administration's ongoing review of U.S. climate change policy. In particular, the written request (Appendix A) asked for the National Academies' "assistance in identifying theareas in the science of climate change where there are the greatest certainties and uncertainties," and "views on whether there are any substantive differences between the IPCC [Intergovernmental Panel on Climate Change] Reports and the IPCC summaries."In addition, based on discussions with the Administration, the following specific questions were incorporated into the statement of task for the study:

- *What is the range of natural variability in climate?*
- *Are concentrations of greenhouse gases and other emissions that contribute to climate change increasing at an accelerating rate, and are different greenhouse gases and other emissions increasing at different rates?*
- *How long does it take to reduce the buildup of greenhouse gases and other emissions that contribute to climate change?*
- *What other emissions are contributing factors to climate change (e.g., aerosols, CO, black carbon soot), and what is their relative contribution to climate change?*
- *Do different greenhouse gases and other emissions have different draw down periods?*
- *Are greenhouse gases causing climate change?*
- *Is climate change occurring? If so, how?*
- *Is human activity the cause of increased concentrations of greenhouse gases and other emissions that contribute to climate change?*
- *How much of the expected climate change is the consequence of climate feedback processes (e.g., water vapor,*

clouds, snow packs)?

- *By how much will temperatures change over the next 100 years and where?*
- *What will be the consequences (e.g., extreme weather, health effects) of increases of various magnitudes?*
- *Has science determined whether there is a "safe" level of concentration of greenhouse gases?*
- *What are the substantive differences between the IPCC Reports and the Summaries?*
- *What are the specific areas of science that need to be studied further, in order of priority, to advance our understanding of climate change?*

The White House asked for a response "as soon as possible" but no later than early June—less than one month after submitting its formal request.

The National Academies has a mandate arising from its 1863 charter to respond to government requests when asked. In view of the critical nature of this issue, we agreed to undertake this study and to use our own funds to support it.

A distinguished committee with broad expertise and diverse perspectives on the scientific issues of climate change was therefore appointed through the National Academies' National Research Council (see Appendix B for biographical information on committee members). In early May, the committee held a conference call to discuss the specific questions and to prepare for its 2-day meeting (May 21-22, 2001) in Irvine, California. The committee reviewed the 14 questions and determined that they represent important issues in climate change science and could serve as a useful framework for addressing the two general questions from the White House.

For the task of comparing IPCC Reports and Summaries, the committee focused its review on the work of IPCC Working

Group I, which dealt with many of the same detailed questions being asked above. The committee decided to address the questions in the context of a brief document that also could serve as a primer for policy makers on climate change science. To aid in the presentation, the questions have been organized into seven sections, with the questions addressed in each section listed in *italics* at the beginning of that section.

While traditional procedures for an independent NRC study, including review of the report by independent experts, were followed, it is important to note that tradeoffs were made in order to accommodate the rapid schedule. For example, the report does not provide extensive references to the scientific literature or marshal detailed evidence to support its "answers" to the questions. Rather, the report largely presents the consensus scientific views and judgments of committee members, based on the accumulated knowledge that these individuals have gained—both through their own scholarly efforts and through formal and informal interactions with the world's climate change science community.

The result is a report that, in my view, provides policy makers with a succinct and balanced overview of what science can currently say about the potential for future climate change, while outlining the uncertainties that remain in our scientific knowledge.

The report does not make policy recommendations regarding what to do about the potential of global warming. Thus, it does not estimate the potential economic and environmental costs, benefits, and uncertainties regarding various policy responses andfuture human behaviors. While beyond the charge presented to this committee, scientists and social scientists have the abilityto provide assessments of this type as well. Both types of assessments can be helpful to policy makers, who frequently have to weigh tradeoffs and make decisions on important issues, despite the inevitable

uncertainties in our scientific understanding concerning particular aspects. Science never has all the answers. But science does provide us with the best available guide to the future, and it is critical that our nation and the world base important policies on the best judgments that science can provide concerning the future consequences of present actions.

I would especially like to thank the members of this committee and its staff for an incredible effort in producing this important report in such a short period of time. They have sacrificed many personal commitments and worked long weekends to provide the nation with their considered judgments on this critical issue.

Bruce Alberts
President
National Academy of Sciences

Acknowledgments

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

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Although the reviewers listed above have provided constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations nor did they see the final draft of the report before its release. The review of this report was overseen by Richard M. Goody (Harvard University) and Robert A. Frosch (Harvard University). Appointed by the National Research Council, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authoring committee and the institution.

We would also like to thank the following individuals for their input regarding the IPCC process: John Christy, Haroon Kheshgi, Michael Mann, Jerry Meehl, Berrien Moore, Michael Oppenheimer, Joyce Penner, Ray Pierrehumbert, Michael Prather, Venkatachalam Ramaswamy, Ben Santer, Piers Sellers, Susan Solomon, Ron Stouffer, Kevin Trenberth, and Robert Watson.

Contents

APPENDIXES

Summary

Greenhouse gases are accumulating in Earth's atmosphere as a result of human activities, causing surface air temperatures and subsurface ocean temperatures to rise. Temperatures are, in fact, rising. The changes observed over the last several decades are likely mostly due to human activities, but we cannot rule out that some significant part of these changes is also a reflection of natural variability. Human-induced warming and associated sea level rises are expected to continue through the 21st century. Secondary effects are suggested by computer model simulations and basic physical reasoning. These include increases in rainfall rates and increased susceptibility of semi-arid regions to drought. The impacts of these changes will be critically dependent on the magnitude of the warming and the rate with which it occurs.

The mid-range model estimate of human induced global warming by the Intergovernmental Panel on Climate Change (IPCC) is based on the premise that the growth rate of climate forcing[1] agents such as carbon dioxide will accelerate. The predicted warming of 3°C (5.4°F) by the end of the 21st century is consistent with the assumptions about how clouds and atmospheric relative humidity will react to global warming. This estimate is also consistent with inferences about the sensitivity[2] of climate drawn from comparing the sizes of past temperature swings between ice ages and intervening warmer periods with the corresponding changes in the climate forcing.

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[1] A climate forcing is defined as an imposed perturbation of Earth's energy balance. Climate forcing is typically measured in watts per square meter (W/m2).

[2] The sensitivity of the climate system to a prescribed forcing is commonly expressed in terms of the global mean temperature change that would be expected after a time sufficiently long for both the atmosphere and ocean to come to equilibrium with the change in climate forcing.

This predicted temperature increase is sensitive to assumptions concerning future concentrations of greenhouse gases and aerosols. Hence, national policy decisions made now and in the longer-term future will influence the extent of any damage suffered by vulnerable human populations and ecosystems later in this century. Because there is considerable uncertainty in current understanding of how the climate system varies naturally and reacts to emissions of greenhouse gases and aerosols, current estimates of the magnitude of future warming should be regarded as tentative and subject to future adjustments (either upward or downward).

Reducing the wide range of uncertainty inherent in current model predictions of global climate change will require major advances in understanding and modeling of both (1) the factors that determine atmospheric concentrations of greenhouse gases and aerosols, and (2) the so-called "feedbacks" that determine the sensitivity of the climate system to a prescribed increase in greenhouse gases. There also is a pressing need for a global observing system designed for monitoring climate.

The committee generally agrees with the assessment of human-caused climate change presented in the IPCC Working Group I (WGI) scientific report, but seeks here to articulate more clearly the level of confidence that can be ascribed to those assessments and the caveats that need to be attached to them. This articulation may be helpful to policy makers as they consider a variety of options for mitigation and/or adaptation. In the sections that follow, the committee provides brief responses to some of the key questions related to climate change science. More detailed responses to these questions are located in the main body of the text.

What is the range of natural variability in climate?

The range of natural climate variability is known to be quite

large (in excess of several degrees Celsius) on local and regional spatial scales over periods as short as a decade. Precipitation also can vary widely. For example, there is evidence to suggest that droughts as severe as the "dust bowl" of the 1930s were much more common in the central United States during the 10th to 14th centuries than they have been in the more recent record. Mean temperature variations at local sites have exceeded 10°C (18°F) in association with the repeated glacial advances and retreats that occurred over the course of the past million years. It is more difficult to estimate the natural variability of global mean temperature because of the sparse spatial coverage of existing data and difficulties in inferring temperatures from various proxy data. Nonetheless, evidence suggests that global warming rates as large as 2°C (3.6°F) per millennium may have occurred during retreat of the glaciers following the most recent ice age.

Are concentrations of greenhouse gases and other emissions that contribute to climate change increasing at an accelerating rate, and are different greenhouse gases and other emissions increasing at different rates? Is human activity the cause of increased concentrations of greenhouse gases and other emissions that contribute to climate change?

The emissions of some greenhouse gases are increasing, but others are decreasing. In some cases the decreases are a result of policy decisions, while in other cases the reasons for the decreases are not well understood.

Of the greenhouse gases that are directly influenced by human activity, the most important are carbon dioxide, methane, ozone, nitrous oxide, and chlorofluorocarbons (CFCs). Aerosols released by human activities are also capable of influencing climate. (Table 1 lists the estimated climate forcing due to the presence of each of these "climate forcing

agents" in the atmosphere.)

Concentrations of carbon dioxide (CO_2) extracted from ice cores drilled in Greenland and Antarctica have typically ranged from near 190 parts per million by volume (ppmv) during the ice ages to near 280 ppmv during the warmer "interglacial" periods like the present one that began around 10,000 years ago. Concentrations did not rise much above 280 ppmv until the Industrial Revolution. By 1958, when systematic atmospheric measurements began, they had reached 315 ppmv, and they are currently ~370 ppmv and rising at a rate of 1.5 ppmv per year (slightly higher than the rate during the early years of the 43-year record). Human activities are responsible for the increase. The primary source, fossil fuel burning, has released roughly twice as much carbon dioxide as would be required to account for the observed increase. Tropical deforestation also has contributed to carbon dioxide releases during the past few decades. The excess carbon dioxide has been taken up by the oceans and land biosphere.

Like carbon dioxide, methane (CH_4) is more abundant in Earth's atmosphere now than at any time during the 400,000 year long ice core record, which dates back over a number of glacial/interglacial cycles. Concentrations increased rather smoothly by about 1% per year from 1978, until about 1990. The rate of increase slowed and became more erratic during the 1990s. About two-thirds of the current emissions of methane are released by human activities such as rice growing, the raising of cattle, coal mining, use of land-fills, and natural gas handling, all of which have increased over the past 50 years.

A small fraction of the ozone (O_3) produced by natural processes in the stratosphere mixes into the lower atmosphere. This "tropospheric ozone" has been supplemented during the 20th century by additional ozone, created locally by the action of sunlight upon air polluted by exhausts from motor vehicles, emissions from fossil fuel burning power plants, and biomass

burning.

Nitrous oxide (N_2O) is formed by many microbial reactions in soils and waters, including those acting on the increasing amounts of nitrogen-containing fertilizers. Some synthetic chemical processes that release nitrous oxide have also been identified. Its concentration has increased approximately 13% in the past 200 years.

Atmospheric concentrations of CFCs rose steadily following their first synthesis in 1928 and peaked in the early 1990s. Many other industrially useful fluorinated compounds (e.g., carbon tetrafluoride, CF_4, and sulfur hexafluoride, SF_6), have very long atmospheric lifetimes, which is of concern, even though their atmospheric concentrations have not yet produced large radiative forcings. Hydrofluorocarbons (HFCs), which are replacing CFCs, have a greenhouse effect, but it is much less pronounced because of their shorter atmospheric lifetimes. The sensitivity and generality of modern analytical systems make it quite unlikely that any currently significant greenhouse gases remain to be discovered.

What other emissions are contributing factors to climate change (e.g., aerosols, CO, black carbon soot), and what is their relative contribution to climate change?

Besides greenhouse gases, human activity also contributes to the atmospheric burden of aerosols, which include both sulfate particles and black carbon (soot). Both are unevenly distributed, owing to their short lifetimes in the atmosphere. Sulfate particles scatter solar radiation back to space, thereby offsetting the greenhouse effect to some degree. Recent “clean coal technologies” and use of low sulfur fuels have resulted in decreasing sulfate concentrations, especially in North America, reducing this offset. Black carbon aerosols are end-products of the incomplete combustion of fossil fuels and biomass burning

(forest fires and land clearing). They impact radiation budgets both directly and indirectly; they are believed to contribute to global warming, although their relative importance is difficult to quantify at this point.

How long does it take to reduce the buildup of greenhouse gases and other emissions that contribute to climate change? Do different greenhouse gases and other emissions have different draw down periods?

TABLE 1 Removal Times and Climate Forcing Values for Specified Atmospheric Gases and Aerosols

Forcing Agent	Approximate Removal Times[3]	Climate Forcing (W/m^2) Up to the year 2000
Greenhouse Gases		
Carbon Dioxide	>100 years	1.3 to 1.5
Methane	10 years	0.5 to 0.7
Tropospheric Ozone	10-100 days	0.25 to 0.75
Nitrous Oxide	100 years	0.1 to 0.2
Perfluorocarbon Compounds (Including SF_6)	>1000 years	0.01
Fine Aerosols		
Sulfate	10 days	–0.3 to –1.0
Black Carbon	10 days	0.1 to 0.8

[3]A removal time of 100 years means that much, but not all, of the substance would be gone in 100 years. Typically, the amount remaining at the end of 100 years is 37%; after 200 years 14%; after 300 years 5%; after 400 years 2%.

Is climate change occurring? If so, how?

Weather station records and ship-based observations indicate that global mean surface air temperature warmed between about 0.4 and 0.8°C (0.7 and 1.5°F) during the 20th century. Although the magnitude of warming varies locally, the warming trend is spatially widespread and is consistent with an array of other evidence detailed in this report. The ocean, which represents the largest reservoir of heat in the climate system, has warmed by about 0.05°C (0.09°F) averaged over the layer extending from the surface down to 10,000 feet, since the 1950s.

The observed warming has not proceeded at a uniform rate. Virtually all the 20th century warming in global surface air temperature occurred between the early 1900s and the 1940s and during the past few decades. The troposphere warmed much more during the 1970s than during the two subsequent decades, whereas Earth's surface warmed more during the past two decades than during the 1970s. The causes of these irregularities and the disparities in the timing are not completely understood. One striking change of the past 35 years is the cooling of the stratosphere at altitudes of ~13 miles, which has tended to be concentrated in the wintertime polar cap region.

Are greenhouse gases causing climate change?

The IPCC's conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue. The stated degree of confidence in the IPCC assessment is higher today than it was 10, or even 5 years ago, but uncertainty remains because of (1) the level of natural variability inherent in the climate system on time scales of decades to centuries, (2) the

questionable ability of models to accurately simulate natural variability on those long time scales, and (3) the degree of confidence that can be placed on reconstructions of global mean temperature over the past millennium based on proxy evidence. Despite the uncertainties, there is general agreement that the observed warming is real and particularly strong within the past 20 years. Whether it is consistent with the change that would be expected in response to human activities is dependent upon what assumptions one makes about the time history of atmospheric concentrations of the various forcing agents, particularly aerosols.

By how much will temperatures change over the next 100 years and where?

Climate change simulations for the period of 1990 to 2100 based on the IPCC emissions scenarios yield a globally-averaged surface temperature increase by the end of the century of 1.4 to 5.8°C (2.5 to 10.4°F) relative to 1990. The wide range of uncertainty in these estimates reflects both the different assumptions about future concentrations of greenhouse gases and aerosols in the various scenarios considered by the IPCC and the differing climate sensitivities of the various climate models used in the simulations. The range of climate sensitivities implied by these predictions is generally consistent with previously reported values.

The predicted warming is larger over higher latitudes than over low latitudes, especially during winter and spring, and larger over land than over sea. Rainfall rates and the frequency of heavy precipitation events are predicted to increase, particularly over the higher latitudes. Higher evaporation rates would accelerate the drying of soils following rain events, resulting in lower relative humidities and higher daytime temperatures, especially during the warm season. The

likelihood that this effect could prove important is greatest in semi-arid regions, such as the U.S. Great Plains. These predictions in the IPCC report are consistent with current understanding of the processes that control local climate.

In addition to the IPCC scenarios for future increases in greenhouse gas concentrations, the committee considered a scenario based on an energy policy designed to keep climate change moderate in the next 50 years. This scenario takes into account not only the growth of carbon emissions, but also the changing concentrations of other greenhouse gases and aerosols.

Sufficient time has elapsed now to enable comparisons between observed trends in the concentrations of carbon dioxide and other greenhouse gases with the trends predicted in previous IPCC reports. The increase of global fossil fuel carbon dioxide emissions in the past decade has averaged 0.6% per year, which is somewhat below the range of IPCC scenarios, and the same is true for atmospheric methane concentrations. It is not known whether these slowdowns in growth rate will persist.

How much of the expected climate change is the consequence of climate feedback processes (e.g., water vapor, clouds, snow packs)?

The contribution of feedbacks to the climate change depends upon "climate sensitivity," as described in the report. If a central estimate of climate sensitivity is used, about 40% of the predicted warming is due to the direct effects of greenhouse gases and aerosols. The other 60% is caused by feedbacks. Water vapor feedback (the additional greenhouse effect accruing from increasing concentrations of atmospheric water vapor as the atmosphere warms) is the most important feedback in the models. Unless the relative humidity in the tropical

middle and upper troposphere drops, this effect is expected to increase the temperature response to increases in human induced greenhouse gas concentrations by a factor of 1.6. The ice-albedo feedback (the reduction in the fraction of incoming solar radiation reflected back to space as snow and ice cover recede) also is believed to be important. Together, these two feedbacks amplify the simulated climate response to the greenhouse gas forcing by a factor of 2.5. In addition, changes in cloud cover, in the relative amounts of high versus low clouds, and in the mean and vertical distribution of relative humidity could either enhance or reduce the amplitude of the warming. Much of the difference in predictions of global warming by various climate models is attributable to the fact that each model represents these processes in its own particular way. These uncertainties will remain until a more fundamental understanding of the processes that control atmospheric relative humidity and clouds is achieved.

What will be the consequences (e.g., extreme weather, health effects) of increases of various magnitude?

In the near term, agriculture and forestry are likely to benefit from carbon dioxide fertilization and an increased water efficiency of some plants at higher atmospheric CO_2 concentrations. The optimal climate for crops may change, requiring significant regional adaptations. Some models project an increased tendency toward drought over semi-arid regions, such as the U.S. Great Plains. Hydrologic impacts could be significant over the western United States, where much of the water supply is dependent on the amount of snow pack and the timing of the spring runoff. Increased rainfall rates could impact pollution run-off and flood control. With higher sea level, coastal regions could be subject to increased wind and flood damage even if tropical storms do not change in intensity.

A significant warming also could have far reaching implications for ecosystems. The costs and risks involved are difficult to quantify at this point and are, in any case, beyond the scope of this brief report.

Health outcomes in response to climate change are the subject of intense debate. Climate is one of a number of factors influencing the incidence of infectious disease. Coldrelated stress would decline in a warmer climate, while heat stress and smog induced respiratory illnesses in major urban areas would increase, if no adaptation occurred. Over much of the United States, adverse health outcomes would likely be mitigated by a strong public health system, relatively high levels of public awareness, and a high standard of living.

Global warming could well have serious adverse societal and ecological impacts by the end of this century, especially if globally-averaged temperature increases approach the upper end of the IPCC projections. Even in the more conservative scenarios, the models project temperatures and sea levels that continue to increase well beyond the end of this century, suggesting that assessments that examine only the next 100 years may well underestimate the magnitude of the eventual impacts.

Has science determined whether there is a "safe" level of concentration of greenhouse gases?

The question of whether there exists a "safe" level of concentration of greenhouse gases cannot be answered directly because it would require a value judgment of what constitutes an acceptable risk to human welfare and ecosystems in various parts of the world, as well as a more quantitative assessment of the risks and costs associated with the various impacts of global warming. In general, however, risk increases with increases in both the rate and the magnitude of climate change.

What are the substantive differences between the IPCC Reports and the Summaries?

The committee finds that the full IPCC Working Group I (WGI) report is an admirable summary of research activities in climate science, and the full report is adequately summarized in the *Technical Summary*. The full WGI report and its *Technical Summary* are not specifically directed at policy. The *Summary for Policymakers* reflects less emphasis on communicating the basis for uncertainty and a stronger emphasis on areas of major concern associated with human induced climate change. This change in emphasis appears to be the result of a summary process in which scientists work with policy makers on the document. Written responses from U.S. coordinating and lead scientific authors to the committee indicate, however, that (a) no changes were made without the consent of the convening lead authors (this group represents a fraction of the lead and contributing authors) and (b) most changes that did occur lacked significant impact.

It is critical that the IPCC process remain truly representative of the scientific community. The committee's concerns focus primarily on whether the process is likely to become less representative in the future because of the growing voluntary time commitment required to participate as a lead or coordinating author and the potential that the scientific process will be viewed as being too heavily influenced by governments which have specific postures with regard to treaties, emission controls, and other policy instruments. The United States should promote actions that improve the IPCC process while also ensuring that its strengths are maintained.

What are the specific areas of science that need to be studied further, in order of priority, to advance our understanding of climate change?

Making progress in reducing the large uncertainties in projections of future climate will require addressing a number of fundamental scientific questions relating to the buildup of greenhouses gases in the atmosphere and the behavior of the climate system. Issues that need to be addressed include (a) the future usage of fossil fuels, (b) the future emissions of methane, (c) the fraction of the future fossil-fuel carbon that will remain in the atmosphere and provide radiative forcing versus exchange with the oceans or net exchange with the land biosphere, (d) the feedbacks in the climate system that determine both the magnitude of the change and the rate of energy uptake by the oceans, which together determine the magnitude and time history of the temperature increases for a given radiative forcing, (e) details of the regional and local climate change consequent to an overall level of global climate change, (f) the nature and causes of the natural variability of climate and its interactions with forced changes, and (g) the direct and indirect effects of the changing distributions of aerosols. Maintaining a vigorous, ongoing program of basic research, funded and managed independently of the climate assessment activity, will be crucial for narrowing these uncertainties.

In addition, the research enterprise dealing with environmental change and the interactions of human society with the environment must be enhanced. This includes support of (a) interdisciplinary research that couples physical, chemical, biological, and human systems, (b) an improved capability of integrating scientific knowledge, including its uncertainty, into effective decision support systems, and (c) an ability to conduct research at the regional or sectoral level that promotes analysis of the response of human and natural systems to multiple stresses.

An effective strategy for advancing the understanding of

climate change also will require (1) a global observing system in support of long-term climate monitoring and prediction, (2) concentration on large-scale modeling through increased, dedicated supercomputing and human resources, and (3) efforts to ensure that climate research is supported and managed to ensure innovation, effectiveness, and efficiency.

1

Climate, Climate Forcings, Climate Sensitivity, and Transient Climate Change

CLIMATE

Climate is the average state of the atmosphere and the underlying land or water, on time scales of seasons and longer. Climate is typically described by the statistics of a set of atmospheric and surface variables, such as temperature, precipitation, wind, humidity, cloudiness, soil moisture, sea surface temperature, and the concentration and thickness of sea ice. The statistics may be in terms of the long-term average, as well as other measures such as daily minimum temperature, length of the growing season, or frequency of floods. Although climate and climate change are usually presented in global mean terms, there may be large local and regional departures from these global means. These can either mitigate or exaggerate the impact of climate change in different parts of the world.

A number of factors contribute to climate and climate change, and it is useful to define the terms climate forcings, climate sensitivity, and transient climate change for discussion below.

CLIMATE FORCINGS

A climate forcing can be defined as an imposed perturbation of Earth's energy balance. Energy flows in from the sun, much of it in the visible wavelengths, and back out again as long-wave infrared (heat) radiation. An increase in the luminosity of the sun, for example, is a positive forcing that tends to make Earth warmer. A very large volcanic eruption, on the other hand, can increase the aerosols (fine particles) in the lower stratosphere (altitudes of 10-15 miles) that reflect sunlight to space and thus reduce the solar energy delivered to Earth's surface. These examples are natural forcings. Human-made forcings result from, for example, the gases and aerosols produced by fossil fuel burning, and alterations of Earth's surface from various changes in land use, such as the conversion of forests into agricultural land. Those gases that absorb infrared radiation, i.e., the "greenhouse" gases, tend to prevent this heat radiation from escaping to space, leading eventually to a warming of Earth's surface. The observations of human-induced forcings underlie the current concerns about climate change.

The common unit of measure for climatic forcing agents is the energy perturbation that they introduce into the climate system, measured in units of watts per square meter (W/m2). The consequences from such forcings are often then expressed as the change in average global temperature, and the conversion factor from forcing to temperature change is the sensitivity of Earth's climate system. Although some forcings—volcanic plumes, for example—are not global in nature and temperature change may also not be uniform, comparisons of the strengths of individual forcings, over comparable areas, are useful for estimating the relative importance of the various processes that may cause climate change.

CLIMATE SENSITIVITY

The sensitivity of the climate system to a forcing is commonly expressed in terms of the global mean temperature change that would be expected after a time sufficiently long for both the atmosphere and ocean to come to equilibrium with the change in climate forcing. If there were no climate feedbacks, the response of Earth's mean temperature to a forcing of 4 W/m2 (the forcing for a doubled atmospheric CO_2) would be an increase of about 1.2°C (about 2.2°F). However, the total climate change is affected not only by the immediate direct forcing, but also by climate "feedbacks" that come into play in response to the forcing. For example, a climate forcing that causes warming may melt some of the sea ice. This is a positive feedback because the darker ocean absorbs more sunlight than the sea ice it replaced. The responses of atmospheric water vapor amount and clouds probably generate the most important global climate feedbacks. The nature and magnitude of these hydrologic feedbacks give rise to the largest source of uncertainty about climate sensitivity, and they are an area of continuing research.

As just mentioned, a doubling of the concentration of carbon dioxide (from the pre-Industrial value of 280 parts per million) in the global atmosphere causes a forcing of 4 W/ m2. The central value of the climate sensitivity to this change is a global average temperature increase of 3°C (5.4°F), but with a range from 1.5°C to 4.5°C (2.7 to 8.1°F) (based on climate system models: see section 4). The central value of 3°C is an amplification by a factor of 2.5 over the direct effect of 1.2°C (2.2°F). Well-documented climate changes during the history of Earth, especially the changes between the last major ice age (20,000 years ago) and the current warm period, imply that the climate sensitivity is near the 3°C value. However, the true climate sensitivity remains uncertain, in part because it is

difficult to model the effect of cloud feedback. In particular, the magnitude and even the sign of the feedback can differ according to the composition, thickness, and altitude of the clouds, and some studies have suggested a lesser climate sensitivity. On the other hand, evidence from paleoclimate variations indicates that climate sensitivity could be higher than the above range, although perhaps only on longer time scales.

TRANSIENT CLIMATE CHANGE

Climate fluctuates in the absence of any change in forcing, just as weather fluctuates from day to day. Climate also responds in a systematic way to climate forcings, but the response can be slow because the ocean requires time to warm (or cool) in response to the forcing. The response time depends upon the rapidity with which the ocean circulation transmits changes in surface temperature into the deep ocean. If the climate sensitivity is as high as the 3°C mid-range, then a few decades are required for just half of the full climate response to be realized, and at least several centuries for the full response.[1]

Such a long climate response time complicates the climate change issue for policy makers because it means that a discovered undesirable climate change is likely to require many decades to halt or reverse.

Increases in the temperature of the ocean that are initiated in the next few decades will continue to raise sea level by ocean thermal expansion over the next several centuries. Although society might conclude that it is practical to live with substantial climate change in the coming decades, it is also important to consider further consequences that may occur in

[1] The time required for the full response to be realized depends, in part, on the rate of heat transfer from the ocean mixed layer to the deeper ocean. Slower transfer leads to shorter response times on Earth's surface.

later centuries. The climate sensitivity and the dynamics of large ice sheets become increasingly relevant on such longer time scales.

It is also possible that climate could undergo a sudden large change in response to accumulated climate forcing. The paleoclimate record contains examples of sudden large climate changes, at least on regional scales. Understanding these rapid changes is a current research challenge that is relevant to the analysis of possible anthropogenic climate effects.

2

Natural Climatic Variations

What is the range of natural variability in climate?

Climate is continually varying on time scales ranging from seasons to the lifetime of Earth. Natural climate changes can take place on short time scales as a result of the rapid alterations to forcings (as described in section 1). For example, the injection of large quantities of sulfur dioxide (SO_2), which changes to sulfuric acid droplets, and fine particulate material into the stratosphere (the region between 10 and 30 miles altitude where the temperature rises with increasing altitude) by major volcanic eruptions like that of Mt. Pinatubo in 1991 can cause intervals of cooler than average global temperatures. Climate variability also can be generated by processes operating within the climate system— the periodic rapid warming trend in the eastern Pacific Ocean known as El Niño being perhaps the best known example. Each of these different processes produces climate variability with its own characteristic spatial and seasonal signature. For example, El Niño typically brings heavy rainstorms to coastal Ecuador, Peru, and California and droughts to Indonesia and Northeast

Brazil.

Over long time scales, outside the time period in which humans could have a substantive effect on global climate (e.g., prior to the Industrial Revolution), proxy data (information derived from the content of tree rings, cores from marine sediments, pollens, etc.) have been used to estimate the range of natural climate variability. An important recent addition to the collection of proxy evidence is ice cores obtained by international teams of scientists drilling through miles of ice in Antarctica and at the opposite end of the world in Greenland. The results can be used to make inferences about climate and atmospheric composition extending back as long as 400,000 years. These and other proxy data indicate that the range of natural climate variability is in excess of several degrees C on local and regional space scales over periods as short as a decade. Precipitation has also varied widely. For example, there is evidence to suggest that droughts as severe as the "dust bowl" of the 1930s were much more common in the central United States during the 10th to 14th centuries than they have been in the more recent record.

Temperature variations at local sites have exceeded 10°C (18°F) in association with the repeated glacial advances and retreats that occurred over the course of the past million years. It is more difficult to estimate the natural variability of global mean temperature because large areas of the world are not sampled and because of the large uncertainties inherent in temperatures inferred from proxy evidence. Nonetheless, evidence suggests that global warming rates as large as 2°C (3.6°F) per millennium may have occurred during the retreat of the glaciers following the most recent ice age.

3

Human Caused Forcings

Are concentrations of greenhouse gases and other emissions that contribute to climate change increasing at an accelerating rate, and are different greenhouse gases and other emissions increasing at different rates?

Is human activity the cause of increased concentrations of greenhouse gases and other emissions that contribute to climate change?

What other emissions are contributing factors to climate change (e.g., aerosols, CO, black carbon soot), and what is their relative contribution to climate change?

How long does it take to reduce the buildup of greenhouse gases and other emissions that contribute to climate change?

Do different greenhouse gases and other emissions have different draw down periods?

Are greenhouse gases causing climate change?

GREENHOUSE GASES

The most important greenhouse gases in Earth's atmosphere include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), water vapor (H_2O), ozone (O_3), and the chlorofluorocarbons (CFCs including CFC-12 (CCl_2F_2) and CFC-11 (CCl_3F)). In addition to reflecting sunlight, clouds are also a major greenhouse substance. Water vapor and cloud droplets are in fact the dominant atmospheric absorbers, and

how these substances respond to climate forcings is a principal determinant of climate sensitivity, as discussed in Section 1. The CO_2, CH_4, N_2O and H_2O are both produced and utilized in many biological processes, although the major source of gaseous water is evaporation from the oceans. Ozone is created in the atmosphere by reactions initiated by sunlight. The CFCs are synthetic compounds developed and released into the atmosphere by humankind. In addition, sulfur hexafluoride (SF_6) and perfluorocarbon gases such as carbon tetrafluoride (CF_4) are very potent and nearly inert greenhouse gases with atmospheric lifetimes much longer than 1000 years.

The natural atmosphere contained many greenhouse gases whose atmospheric concentrations were determined by the sum of the ongoing geophysical, biological, and chemical reactions that produce and destroy them. The specific effects of humankind's activities before the industrial era were immersed in all of the natural dynamics and became noticeable only in the immediate vicinity, as with the smoke from small fires. The theoretical realization that human activities could have a global discernible effect on the atmosphere came during the 19th century, and the first conclusive measurements of atmospheric change were made during the last half of the 20th century. The first greenhouse gas demonstrated to be increasing in atmospheric concentration was carbon dioxide, formed as a major end product in the extraction of energy from the burning of the fossil fuels—coal, oil, and natural gas—as well as in the burning of biomass.

The common characteristics of greenhouse gases are (1) an ability to absorb terrestrial infrared radiation and (2) a presence in Earth's atmosphere. The most important greenhouse gases listed above all contain three or more atoms per molecule. Literally thousands of gases have been identified as being present in the atmosphere at some place and at some time, and all but a few have the ability to absorb terrestrial infrared

radiation. However, the great majority of these chemical compounds, both natural[1] and anthropogenic, are removed in hours, days, or weeks, and do not accumulate in significant concentrations. Some can have an indirect greenhouse effect, as with carbon monoxide (CO).[2] If the average survival time for a gas in the atmosphere is a year or longer, then the winds have time to spread it throughout the lower atmosphere, and its absorption of terrestrial infrared radiation occurs at all latitudes and longitudes. All the listed greenhouse gases except ozone are released to the atmosphere at Earth's surface and are spread globally throughout the lower atmosphere. The lifetime of CH_4 in the atmosphere is 10-12 years. Nitrous oxide and the CFCs have century-long lifetimes before they are destroyed in the stratosphere. Atmospheric CO_2 is not destroyed chemically, and its removal from the atmosphere takes place through multiple processes that transiently store the carbon in the land and ocean reservoirs, and ultimately as mineral deposits. A major removal process depends on the transfer of the carbon content of near-surface waters to the deep ocean, which has a century time scale, but final removal stretches out over hundreds of thousands of years. Reductions in the atmospheric concentrations of these gases following possible lowered emission rates in the future will stretch out over decades for methane, and centuries and longer for carbon dioxide and nitrous oxide.

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[1] While the activities of mankind are part of the natural world, the convention exists in most discussions of the atmosphere that "natural processes" are those that would still exist without the presence of human beings; those processes that are significantly influenced by humans are called "anthropogenic".

[2] Both carbon monoxide and methane are removed from the atmosphere by chemical reaction with hydroxyl (OH). An increase in the carbon monoxide uses up hydroxyl, slowing methane removal and allowing its concentration and greenhouse effect to increase.

Methane, nitrous oxide, and ozone all have natural sources, but they can also be introduced into the atmosphere by the activities of humankind. These supplementary sources have contributed to the increasing concentrations of these gases during the 20th century.

Carbon Dioxide

While all of the major greenhouse gases have both natural and anthropogenic atmospheric sources, the nature of these processes varies widely among them. Carbon dioxide is naturally absorbed and released by the terrestrial biosphere as well as by the oceans. Carbon dioxide is also formed by the burning of wood, coal, oil, and natural gas, and these activities have increased steadily during the last two centuries since the Industrial Revolution. That the burning of fossil fuels is a major cause of the CO_2 increase is evidenced by the concomitant decreases in the relative abundance of both the stable and radioactive carbon isotopes[3] and the decrease in atmospheric oxygen. Continuous high-precision measurements have been made of its atmospheric concentrations only since 1958, and by the year 2000 the concentrations had increased 17% from 315 parts per million by volume (ppmv) to 370 ppmv. While the year-to-year increase varies, the average annual increase of 1.5 ppmv/year over the past two decades is slightly greater than during the 1960s and 1970s. A marked seasonal oscillation of carbon dioxide concentration exists, especially in the northern hemisphere because of the extensive draw down of carbon dioxide every spring and summer as the green plants convert carbon dioxide into plant material, and the return in the rest of

[3] Fossil fuels are of biological origin and are depleted in both the stable isotope 13C and the radioactive isotope 14C, which has a half-life of 5600 years.

the year as decomposition exceeds photosynthesis. The seasonal effects are quite different north and south of the equator, with the variation much greater in the northern hemisphere where most of Earth's land surface and its vegetation and soils are found.

The atmospheric CO_2 increase over the past few decades is less than the input from human activities because a fraction of the added CO_2 is removed by oceanic and terrestrial processes. Until recently, the partitioning of the carbon sink between the land and sea has been highly uncertain, but recent high-precision measurements of the atmospheric oxygen:nitrogen (O_2:N_2) ratio have provided a crucial constraint: fossil fuel burning and terrestrial uptake processes have different O_2:CO_2 ratios, whereas the ocean CO_2 sink has no significant impact on atmospheric O_2. The atmospheric CO_2 increase for the 1990s was about half the CO_2 emission from fossil fuel combustion, with the oceans and land both serving as important repositories of the excess carbon, i.e., as carbon sinks.

Land gains and loses carbon by various processes: some natural-like photosynthesis and decomposition, some connected to land use and land management practices, and some responding to the increases of carbon dioxide or other nutrients necessary for plant growth. These gains or losses dominate the net land exchange of carbon dioxide with the atmosphere, but some riverine loss to oceans is also significant. Most quantifiable, as by forest and soil inventories, are the above- and below-ground carbon losses from land clearing and the gains in storage in trees from forest recovery and management. Changes in the frequency of forest fires, such as from fire suppression policies, and agricultural practices for soil conservation may modify the carbon stored by land. Climate variations, through their effects on plant growth and decomposition of soil detritus, also have large effects on terrestrial carbon fluxes and storage on a year-to-year basis.

Land modifications, mainly in the middle latitudes of the northern hemisphere, may have been a net source of carbon dioxide to the atmosphere over much of the last century. However, quantitative estimates have only been possible over the last two decades, when forest clearing had shifted to the tropics. In the 1980s land became a small net sink for carbon, that is, the various processes storing carbon globally exceeded the loss due to tropical deforestation, which by itself was estimated to add 10-40% as much carbon dioxide to the atmosphere as burning of fossil fuels. In the 1990s the net storage on land became much larger, nearly as large as the ocean uptake. How land contributes, by location and processes, to exchanges of carbon with the atmosphere is still highly uncertain, as is the possibility that the substantial net removal will continue to occur very far into the future.[4]

Methane

Methane is the major component of natural gas and it is also formed and released to the atmosphere by many biologic processes in low oxygen environments, such as those occurring in swamps, near the roots of rice plants, and the stomachs of cows. Such human activities as rice growing, the raising of cattle, coal mining, use of land-fills, and naturalgas handling have increased over the last 50 years, and direct and inadvertent emissions from these activities have been partially responsible for the increase in atmospheric methane. Its atmospheric concentration has been measured globally and continuously for only two decades, and the majority of the methane molecules

[4] The variations and uncertainties in the land carbon balance are important not only in the contemporary carbon budget. While the terrestrial carbon reservoirs are small compared to the oceans, the possibility of destabilizing land ecosystems and releasing the stored carbon, e.g. from the tundra soils, has been hypothesized.

are of recent biologic origin. The concentrations of methane increased rather smoothly from 1.52 ppmv in 1978 by about 1% per year until about 1990. The rate of increase slowed down to less than that rate during the 1990s, and also became more erratic; current values are around 1.77 ppmv. About two-thirds of the current emissions of methane are released by human activities. There is no definitive scientific basis for choosing among several possible explanations for these variations in the rates of change of global methane concentrations, making it very difficult to predict its future atmospheric concentrations.

Both carbon dioxide and methane were trapped long ago in air bubbles preserved in Greenland and Antarctic ice sheets. These ice sheets are surviving relics of the series of ice ages that Earth experienced over the past 400,000 years. Concentrations of carbon dioxide extracted from ice cores have typically ranged between 190 ppmv during the ice ages to near 280 ppmv during the warmer "interglacial" periods like the present one that began around 10,000 years ago. Concentrations did not rise much above 280 ppmv until the Industrial Revolution. The methane concentrations have also varied during this 400,000 year period, with lowest values of 0.30 ppmv in the coldest times of the ice ages and 0.70 ppmv in the warmest, until a steady rise began about 200 years ago toward the present concentrations. Both carbon dioxide and methane are more abundant in Earth's atmosphere now than at any time during the past 400,000 years.

Other Greenhouse Gases

Nitrous oxide is formed by many microbial reactions in soils and waters, including those processes acting on the increasing amounts of nitrogen-containing fertilizers. Some synthetic chemical processes that release nitrous oxide have also been identified. Its concentration remained about 0.27

ppmv for at least 1,000 years until two centuries ago, when the rise to the current 0.31 ppmv began.

Ozone is created mainly by the action of solar ultraviolet radiation on molecular oxygen in the upper atmosphere, and most of it remains in the stratosphere. However, a fraction of such ozone descends naturally into the lower atmosphere where additional chemical processes can both form and destroy it. This "tropospheric ozone" has been supplemented during the 20th century by additional ozone—an important component of photochemical smog—created by the action of sunlight upon pollutant molecules containing carbon and nitrogen. The most important of the latter include compounds such as ethylene (C_2H_4), carbon monoxide (CO), and nitric oxide released in the exhaust of fossil-fuel-powered motor vehicles and power plants and during combustion of biomass. The lifetime of ozone is short enough that the molecules do not mix throughout the lower atmosphere, but instead are found in broad plumes downwind from the cities of origin, which merge into regional effects, and into a latitude band of relatively high ozone extending from 30°N to 50°N that encircles Earth during Northern Hemisphere spring and summer. The presence of shorter-lived molecules, such as ozone, in the troposphere depends upon a steady supply of newly formed molecules, such as those created daily by traffic in the large cities of the world. The widespread practice of clearing forests and agricultural wastes ("biomass burning"), especially noticeable in the tropics and the Southern Hemisphere, contributes to tropospheric ozone.

The chlorofluorocarbons (CFCs) are different from the gases considered above in that they have no significant natural source but were synthesized for their technological utility. Essentially all of the major uses of the CFCs—as refrigerants, aerosol propellants, plastic foaming agents, cleaning solvents, and so on—result in their release, chemically unaltered, into the

atmosphere. The atmospheric concentrations of the CFCs rose, slowly at first, from zero before first synthesis in 1928, and then more rapidly in the 1960s and 1970s with the development of a widening range of technological applications. The concentrations were rising in the 1980s at a rate of about 18 parts per trillion by volume (pptv) per year for CFC-12, 9 pptv/year for CFC-11, and 6 pptv/year for CFC-113 (CCl_2FCClF_2). Because these molecules were identified as agents causing the destruction of stratospheric ozone,[5] their production was banned in the industrial countries as of January 1996 under the terms of the 1992 revision of the Montreal Protocol, and further emissions have almost stopped. The atmospheric concentrations of CFC-11 and CFC-113 are now slowly decreasing, and that of CFC-12 has been essentially level for the past several years. However, because of the century-long lifetimes of these CFC molecules, appreciable atmospheric concentrations of each will survive well into the 22nd century.

Many other fluorinated compounds (such as carbon tetrafluoride, CF_4, and sulfur hexafluoride, SF_6), also have technological utility, and significant greenhouse gas capabilities. Their very long atmospheric lifetimes are a source of concern even though their atmospheric concentrations have not yet produced large radiative forcings. Members of the class of compounds called hydrofluorocarbons (HFCs) also have a greenhouse effect from the fluorine, but the hydrogen in the molecule allows reaction in the troposphere, reducing both its atmospheric lifetime and the possible greenhouse effect. The atmospheric concentrations of all these gases, which to date are

[5] Eighty-five percent of the mass of the atmosphere lies in the troposphere, the region between the surface and an altitude of about 10 miles. About 90% of Earth's ozone is found in the stratosphere, and the rest is in the troposphere.

only very minor greenhouse contributors, need to be continuously monitored to ensure that no major sources have developed. The sensitivity and generality of modern analytic systems make it unlikely that any additional greenhouse gas will be discovered that is already a significant contributor to the current total greenhouse effect.

AEROSOLS

Sulfate and carbon-bearing compounds associated with particles (i.e., carbonaceous aerosols) are two classes of aerosols that impact radiative balances, and therefore influence climate.

Black Carbon (soot)

The study of the role of black carbon in the atmosphere is relatively new. As a result it is characterized poorly as to its composition, emission source strengths, and influence on radiation. Black carbon is an end product of the incomplete combustion of fossil fuels and biomass, the latter resulting from both natural and human-influenced processes. Most of the black carbon is associated with fine particles (radius $<0.2 \propto$m) that have global residence times of about one week. These lifetimes are considerably shorter than those of most greenhouse gases, and thus the spatial distribution of black carbon aerosol is highly variable, with the greatest concentrations near the production regions. Because of the scientific uncertainties associated with the sources and composition of carbonaceous aerosols, projections of future impacts on climate are difficult. However, the increased burning of fossil fuels and the increased burning of biomass for land clearing may result in increased black carbon concentration globally.

Sulfate

The precursor to sulfate is sulfur dioxide gas, which has two primary natural sources: emissions from marine biota and volcanic emissions. During periods of low volcanic activity, the primary source of sulfur dioxide in regions downwind from continents is the combustion of sulfur-rich coals; less is contributed by other fossil fuels. In oceanic regions far removed from continental regions, the biologic source should dominate. However, model analyses, accounting for the ubiquitous presence of ships, indicate that even in these remote regions combustion is a major source of the sulfur dioxide. Some of the sulfur dioxide attaches to sea-salt aerosol where it is oxidized to sulfate. The sea salt has a residence time in the atmosphere on the order of hours to days, and it is transported in the lower troposphere. Most sulfate aerosol is associated with small aerosols (radius $<1 \propto m$) and is transported in the upper troposphere with an atmospheric lifetime on the order of one week. Recent "clean coal technologies" and the use of low sulfur fossil fuels have resulted in decreasing sulfate concentrations, especially in North America and regions downwind. Future atmospheric concentrations of sulfate aerosols will be determined by the extent of non-clean coal burning techniques, especially in developing nations.

CLIMATE FORCINGS IN THE INDUSTRIAL ERA

Figure 1 summarizes climate forcings that have been introduced during the period of industrial development, between 1750 and 2000, as estimated by the IPCC. Some of these forcings, mainly greenhouse gases, are known quite accurately, while others are poorly measured. A range of uncertainty has been estimated for each forcing, represented by an uncertainty bar or "whisker." However, these estimates are

partly subjective, and it is possible that the true forcing falls outside the indicated range in some cases.

Greenhouse Gases

Carbon dioxide (CO_2) is probably the most important climate forcing agent today, causing an increased forcing of about 1.4 W/m2. CO_2 climate forcing is likely to become more dominant in the future as fossil fuel use continues. If fossil fuels continue to be used at the current rate, the added CO_2 forcing in 50 years will be about 1 W/m2. If fossil fuel use increases by 1-1.5% per year for 50 years, the added CO_2 forcing instead will be about 2 W/m2. These estimates account for the non-linearity caused by partial saturation in some greenhouse gas infrared absorption bands, yet they are only approximate because of uncertainty about how efficiently the ocean and terrestrial biosphere will sequester atmosphericCO_2. The estimates also presume that during the next 50 years humans will not, on a large scale, capture and sequester the

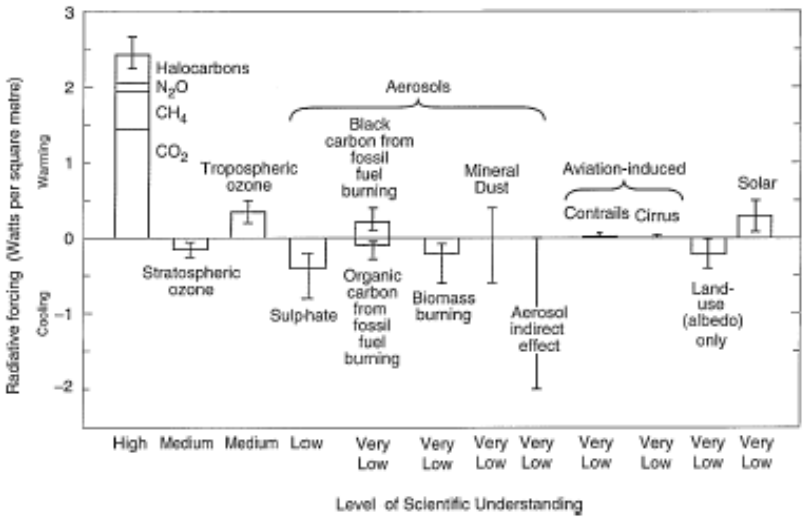

Figure 1 The global mean radiative forcing of the climate system for the year 2000, relative to 1750, and the associated confidence levels with which they are known. (From IPCC, 2001; reprinted with permission of the Intergovernmental Panel on Climate Change.)

CO_2 released during fossil-fuel burning. Other greenhouse gases together cause a climate forcing approximately equal to that of CO_2. Any increase in CH_4 also indirectly causes further climate forcing by increasing stratospheric H_2O (about 7% of the CH_4 is oxidized in the upper atmosphere), as well as by increasing tropospheric O_3 through reactions involving OH and nitrogen oxides. The total climate forcing by CH_4 is at least a third as large as theCO_2 forcing, and it could be half as large as the CO_2 forcing when the indirect effects are included.

Methane is an example of a forcing whose growth could be slowed or even stopped entirely or reversed. The common scenarios for future climate change assume that methane will continue to increase. If instead its amount were to remain constant or decrease, the net climate forcing could be significantly reduced. The growth rate of atmospheric methane

has slowed by more than half in the past two decades for reasons that are not well understood. With a better understanding of the sources and sinks of methane, it may be possible to encourage practices (for example, reduced leakage during fossil-fuel mining and transport, capture of land-fill emissions, and more efficient agricultural practices) that lead to a decrease in atmospheric methane and significantly reduce future climate change. The atmospheric lifetime of methane is of the order of a decade, therefore, unlike CO_2,emission changes will be reflected in changed forcing rather quickly.

Tropospheric ozone (ozone in the lower 5-10 miles of the atmosphere) has been estimated to cause a climate forcing of about 0.4 W/m2. Some of this is linked to methane increases as discussed above, and attribution of the ozone forcing between chemical factors such as methane, carbon monoxide, and other factors is a challenging problem. One recent study, based in part on limited observations of ozone in the late 1800s, suggested that human-made ozone forcing could be as large as about 0.7-0.8 W/m2. Surface level ozone is a major ingredient in air pollution with substantial impacts on human health and agricultural productivity. The potential human and economic gains from reduced ozone pollution and its importance as a climate forcing make it an attractive target for further study as well as possible actions that could lead to reduced ozone amounts or at least a halt in its further growth.

Aerosols

Climate forcing by anthropogenic aerosols is a large source of uncertainty about future climate change. On the basis of estimates of past climate forcings, it seems likely that aerosols, on a global average, have caused a negative climate forcing (cooling) that has tended to offset much of the positive forcing by greenhouse gases. Even though aerosol distributions tend to

be regional in scale, the forced climate response is expected to occur on larger, even hemispheric and global, scales. The monitoring of aerosol properties has not been adequate to yield accurate knowledge of the aerosol climate influence.

Estimates of the current forcing by sulfates fall mainly in the range –0.3 to –1 W/m2. However, the smaller values do not fully account for the fact that sulfate aerosols swell in size substantially in regions of high humidity. Thus, the sulfate forcing probably falls in the range –0.6 to –1 W/m2. Further growth of sulfate aerosols is likely to be limited by concerns about their detrimental effects, especially acid rain, and it is possible that control of sulfur emissions from combustion will even cause the sulfate amount to decrease.

Black carbon (soot) aerosols absorb sunlight and, even though this can cause a local cooling of the surface in regions of heavy aerosol concentration, it warms the atmosphere and, for plausible atmospheric loadings, soot is expected to cause a global surface warming. IPCC reports have provided a best estimate for the soot forcing of 0.1-0.2 W/ m2, but with large uncertainty. One recent study that accounts for the larger absorption that soot can cause when it is mixed internally with other aerosols suggests that its direct forcing is at least 0.4 W/m2. It also has been suggested that the indirect effects of black carbon—which include reducing lowlevel cloud cover (by heating of the layer), making clouds slightly “dirty” (darker), and lowering of the albedo of snow and sea ice—might double this forcing to 0.8 W/m2. The conclusion is that the black carbon aerosol forcing is uncertain but may be substantial. Thus there is the possibility that decreasing black carbon emissions in the future could have a cooling effect that would at least partially compensate for the warming that might be caused by a decrease in sulfates.

Other aerosols are also significant. Organic carbon aerosols are produced naturally by vegetation and anthropogenically in

the burning of fossil fuels and biomass. Organic carbon aerosols thus accompany and tend to be absorbed by soot aerosols, and they are believed to increase the toxicity of the aerosol mixture. It is expected that efforts to reduce emissions of black carbon would also reduce organic carbon emissions. Ammonium nitrate (not included in Figure 1) recently has been estimated to cause a forcing of –0.2 W/m2.

Mineral dust, along with sea salt, sulfates, and organic aerosols, contributes a large fraction of the global aerosol mass. It is likely that human land-use activities have influenced the amount of mineral dust in the air, but trends are not well measured. Except for iron-rich soil, most mineral dust probably has a cooling effect, but this has not been determined well.

The greatest uncertainty about the aerosol climate forcing —indeed, the largest of all the uncertainties about global climate forcings—is probably the indirect effect of aerosols on clouds. Aerosols serve as condensation nuclei for cloud droplets. Thus, anthropogenic aerosols are believed to have two major effects on cloud properties: the increased number of nuclei results in a larger number of smaller cloud droplets, thus increasing the cloud brightness (the Twomey effect), and the smaller droplets tends to inhibit rainfall, thus increasing cloud lifetime and the average cloud cover on Earth. Both effects reduce the amount of sunlight absorbed by Earth and thus tend to cause global cooling. The existence of these effects has been verified in field studies, but it is extremely difficult to determine their global significance. Climate models that incorporate the aerosol-cloud physics suggest that these effects may produce a negative global forcing on the order of 1 W/m2 or larger. The great uncertainty about this indirect aerosol climate forcing presents a severe handicap both for the interpretation of past climate change and for future assessments of climate changes.

Other Forcings

Other potentially important climate forcings include volcanic aerosols, anthropogenic land use, and solar variability. Stratospheric aerosols produced by large volcanoes that eject gas and dust to altitudes of 12 miles or higher can cause a climate forcing as large as several watts per square meter on global average. However, the aerosols fall out after a year or two, so unless there is an unusual series of eruptions, they do not contribute to long-term climate change.

Land-use changes, especially the removal or growth of vegetation, can cause substantial regional climate forcing. One effect that has been evaluated in global climate models is the influence of deforestation. Because forests are dark and tend to mask underlying snow, the replacement of forests by crops or grass yields a higher albedo surface and thus a cooling effect. This effect has been estimated to yield a global cooling tendency in the industrial era equivalent to a forcing of –0.2 W/m2. Land use changes have been an important contributor to past changes of atmospheric carbon dioxide. However, the impacts of such changes on climate may be much more significant on regional scales than globally, and largely act through changes of the hydrologic cycle. Such impacts are currently poorly characterized because they depend on complex modeling details that are still actively being improved.

Solar irradiance, the amount of solar energy striking Earth, has been monitored accurately only since the late 1970s. However, indirect measures of solar activity suggest that there has been a positive trend of solar irradiance over the industrial era, providing a forcing estimated at about 0.3 W/m2. Numerous possible indirect forcings associated with solar variability have been suggested. However, only one of these, ozone changes induced by solar ultraviolet irradiance variations, has convincing observational support. Some studies

have estimated this indirect effect to enhance the direct solar forcing by 0.1 W/m2, but this value remains highly uncertain. Although the net solar forcing appears small in comparison with the sum of all greenhouse gases, it is perhaps more appropriate to compare the solar forcing with the net anthropogenic forcing. Solar forcing is very uncertain, but almost certainly much smaller than the greenhouse gas forcing. It is not implausible that solar irradiance has been a significant driver of climate during part of the industrial era, as suggested by several modeling studies. However, solar forcing has been measured to be very small since 1980, and greenhouse gas forcing has certainly been much larger in the past two decades. In any case, future changes in solar irradiance and greenhouse gases require careful monitoring to evaluate their future balance. In the future, if greenhouse gases continue to increase rapidly while aerosol forcing moderates, solar forcing may be relatively less important. Even in that case, however, the difference between an increasing and decreasing irradiance could be significant and affect interpretation of climate change, so it is important that solar variations be accurately monitored.

4

Climate System Models

Climate system models are an important tool for interpreting observations and assessing hypothetical futures. They are mathematical computer-based expressions of the thermodynamics, fluid motions, chemical reactions, and radiative transfer of Earth climate that are as comprehensive as allowed by computational feasibility and by scientific understanding of their formulation. Their purpose is to calculate the evolving state of the global atmosphere, ocean, land surface, and sea ice in response to external forcings of both natural causes (such as solar and volcanic) and human causes (such as emissions and land uses), given geography and initial material compositions. Such models have been in use for several decades. They are continually improved to increase their comprehensiveness with respect to spatial resolution, temporal duration, biogeochemical complexity, and representation of important effects of processes that cannot practically be calculated on the global scale (such as clouds and turbulent mixing). Formulating, constructing, and using such models and analyzing, assessing, and interpreting their answers make climate system models large and expensive enterprises. For this reason, they are often associated, at least in part, with national laboratories. The rapid increase over recent decades in available computational speed and power offers opportunities for more elaborate, more realistic models, but requires regular upgrading of the basic computers to avoid obsolescence.

Climate models calculate outcomes after taking into account the great number of climate variables and the complex interactions inherent in the climate system. Their purpose is the creation of a synthetic reality that can be compared with the observed reality, subject to appropriate averaging of the

measurements. Thus, such models can be evaluated through comparison with observations, provided that suitable observations exist. Furthermore, model solutions can be diagnosed to assess contributing causes of particular phenomena. Because climate is uncontrollable (albeit influenceable by humans), the models are the only available experimental laboratory for climate. They also are the appropriate high-end tool for forecasting hypothetical climates in the years and centuries ahead. However, climate models are imperfect. Their simulation skill is limited by uncertainties in their formulation, the limited size of their calculations, and the difficulty of interpreting their answers that exhibit almost as much complexity as in nature.

The current norm for a climate system model is to include a full suite of physical representations for air, water, land, and ice with a geographic resolution scale of typically about 250 km. Model solutions match the primary planetary-scale circulation, seasonal variability, and temperature structures with qualitative validity but still some remaining discrepancies. They show forced responses of the global-mean temperature that corresponds roughly with its measured history over the past century, though this requires model adjustments. They achieve a stable equilibrium over millennial intervals with free exchanges of heat, water, and stress across the land and water surfaces. They also exhibit plausible analogues for the dominant modes of intrinsic variability, such as the El Niño/Southern Oscillation (ENSO), although some important discrepancies still remain. At present, climate system models specify solar luminosity, atmospheric composition, and other agents of radiative forcing. A frontier for climate models is the incorporation of more complete biogeochemical cycles (for example, for carbon dioxide). The greater the sophistication and complexity of an atmospheric model, the greater the need for detailed multiple measurements, which test whether the

model continues to mimic observational reality. Applications of climate models to past climate states encompass "snapshots" during particular millennia, but they do not yet provide for continuous evolution over longer intervals (transitions between ice ages).

5

Observed Climate Change During the Industrial Era

Is climate change occurring? If so, how?

Are the changes due to human activities?

THE OCCURRENCE OF CLIMATE CHANGE

A diverse array of evidence points to a warming of global surface air temperatures. Instrumental records from land stations and ships indicate that global mean surface air temperature warmed by about 0.4-0.8°C (0.7-1.5°F) during the 20th century. The warming trend is spatially widespread and is consistent with the global retreat of mountain glaciers, reduction in snow-cover extent, the earlier spring melting of ice on rivers and lakes, the accelerated rate of rise of sea level during the 20th century relative to the past few thousand years, and the increase in upper-air water vapor and rainfall rates over most regions. A lengthening of the growing season also has been documented in many areas, along with an earlier plant flowering season and earlier arrival and breeding of migratory birds. Some species of plants, insects, birds, and fish have shifted towards higher latitudes and higher elevations. The ocean, which represents the largest reservoir of heat in the

climate system, has warmed by about 0.05°C (0.09°F) averaged over the layer extending from the surface down to 10,000 feet, since the 1950s.

Pronounced changes have occurred over high latitudes of the Northern Hemisphere. Analysis of recently declassified data from U.S. and Russian submarines indicates that sea ice in the central Arctic has thinned since the 1970s. Satellite data also indicate a 10-15% decrease in summer sea ice concentration over the Arctic as a whole, which is primarily due to the retreat of the ice over the Siberian sector. A decline of about 10% in spring and summer continental snow cover extent over the past few decades also has been observed. Some of these high latitude changes are believed to be as much or more a reflection of changes in wintertime wind patterns as a direct consequence of global warming per se. The rate of warming has not been uniform over the 20th century. Most of it occurred prior to 1940 and during the past few decades. The Northern Hemisphere as a whole experienced a slight cooling from 1946-75, and the cooling during that period was quite marked over the eastern United States. The cause of this hiatus in the warming is still under debate. The hiatus is evident in averages over both Northern and Southern Hemispheres, but it is more pronounced in the Northern Hemisphere. One possible cause of this feature is the buildup of sulfate aerosols due to the widespread burning of high sulfur coal during the middle of the century, followed by a decline indicated by surface sulfate deposition measurements. It is also possible that at least part of the rapid warming of the Northern Hemisphere during the first part of the 20th century and the subsequent cooling were of natural origin—a remote response to changes in the oceanic circulation at subarctic latitudes in the Atlantic sector, as evidenced by the large local temperature trends over this region. Suggestions that either variations in solar luminosity or the frequency of major volcanic emissions could have

contributed to the irregular rate of warming during the 20th century cannot be excluded.

The IPCC report compares the warming of global mean temperature during the 20th century with the amplitude of climate variations over longer time intervals, making use of recent analyses of tree ring measurements from many different sites, data from the Greenland ice cores, and bore hole temperature measurements. On the basis of these analyses, they conclude that the 0.6°C (1.1°F) warming of the Northern Hemisphere during the 20th century is likely to have been the largest of any century in the past thousand years. This result is based on several analyses using a variety of proxy indicators, some with annual resolution and others with less resolved time resolution. The data become relatively sparse prior to 1600, and are subject to uncertainties related to spatial completeness and interpretation making the results somewhat equivocal, e.g., less than 90% confidence. Achieving greater certainty as to the magnitude of climate variations before that time will require more extensive data and analysis.

Although warming at Earth's surface has been quite pronounced during the past few decades, satellite measurements beginning in 1979 indicate relatively little warming of air temperature in the troposphere. The committee concurs with the findings of a recent National Research Council report,[1] which concluded that the observed difference between surface and tropospheric temperature trends during the past 20 years is probably real, as well as its cautionary statement to the effect that temperature trends based on such short periods of record, with arbitrary start and end points, are not necessarily indicative of the long-term behavior of the climate system. The finding that surface and troposphere temperature trends have been as different as observed over intervals as long as a decade

[1] *Reconciling Observations of Global Temperature Change*, 2000.

or two is difficult to reconcile with our current understanding of the processes that control the vertical distribution of temperature in the atmosphere.

THE EFFECT OF HUMAN ACTIVITIES

Because of the large and still uncertain level of natural variability inherent in the climate record and the uncertainties in the time histories of the various forcing agents (and particularly aerosols), a causal linkage between the buildup of greenhouse gases in the atmosphere and the observed climate changes during the 20th century cannot be unequivocally established. The fact that the magnitude of the observed warming is large in comparison to natural variability as simulated in climate models is suggestive of such a linkage, but it does not constitute proof of one because the model simulations could be deficient in natural variability on the decadal to century time scale. The warming that has been estimated to have occurred in response to the buildup of greenhouse gases in the atmosphere is somewhat greater than the observed warming. At least some of this excess warming has been offset by the cooling effect of sulfate aerosols, and in any case one should not necessarily expect an exact correspondence because of the presence of natural variability.

The cooling trend in the stratosphere, evident in radiosonde data since the 1960s and confirmed by satellite observations starting in 1979, is so pronounced as to be difficult to explain on the basis of natural variability alone. This trend is believed to be partially a result of stratospheric ozone depletion and partially a result of the buildup of greenhouse gases, which warm the atmosphere at low levels but cool it at high levels. The circulation of the stratosphere has responded to the radiatively induced temperature changes in such a way as to concentrate the effects in high latitudes of the winter

hemisphere, where cooling of up to 5°C (9°F) has been observed.

There have been significant changes in the atmospheric circulation during the past several decades: e.g., the transition in climate over the Pacific sector around 1976 that was analogous in some respects to a transition toward more "El Niño-like" conditions over much of the Pacific, and the more gradual strengthening of the wintertime westerlies over subpolar latitudes of both Northern and Southern Hemispheres. Such features bear watching, lest they be early indications of changes in the natural modes of atmospheric variability triggered by human induced climate change. To place them in context, however, it is worth keeping in mind that there were events of comparable significance earlier in the record, such as the 1930s dust bowl.

6

Future Climate Change

How much of the expected climate change is the consequence of climate feedback processes (e.g., water vapor, clouds, snow packs)?

By how much will temperatures change over the next 100 years and where?

What will be the consequences (e.g., extreme weather, health effects) of increases of various magnitude?

Has science determined whether there is a "safe" level of concentration of greenhouse gases?

ESTIMATING FUTURE CLIMATE CHANGE

Projecting future climate change first requires projecting the fossil-fuel and land-use sources of CO_2 and other gases and aerosols. How much of the carbon from future use of fossil fuels will be seen as increases in carbon dioxide in the atmosphere will depend on what fractions are taken up by land and the oceans. The exchanges with land occur on various time scales, out to centuries for soil decomposition in high latitudes, and they are sensitive to climate change. Their projection into the future is highly problematic.

Future climate change depends on the assumed scenario for future climate forcings, as well as upon climate sensitivity. The IPCC scenarios include a broad range of forcings. One scenario often used for climate model studies employs rapid growth rates such that annual greenhouse gas emissions continue to accelerate. This is a useful scenario, in part because it yields a reasonably large "signal/noise" in studies of the simulated climate response. More important, it provides a warning of the magnitude of climate change that may be possible if annual greenhouse gas emissions continue to increase. There are sufficient fossil fuels in the ground to supply such a scenario for well over a century.

IPCC scenarios cover a broad range of assumptions about future economic and technological development, including some that allow greenhouse gas emission reductions. However, there are large uncertainties in underlying assumptions about population growth, economic development, life style choices, technological change, and energy alternatives, so that it is useful to examine scenarios developed from multiple perspectives in considering strategies for dealing with climate

change. For example, one proposed growth scenario[1] for the next 50 years notes that CO_2 emissions have grown by about 1% annually in the past 20 years and assumes a zero growth rate for CO_2 emissions until 2050 (that is, constant emissions). The scenario also focuses on forcings from non-CO_2 greenhouse gases such as methane, and assumes a zero growth rate for them (that is, atmospheric amounts in 2050 similar to those in 2000). Plausible assumptions for technological progress and human factors were proposed to achieve this trajectory for radiative forcing. This scenario leads to a predicted temperature increase of 0.75°C by 2050, approximately half of that resulting from more conventional assumptions. One rationale for focusing first on 2050 rather than 2100 is that it is more difficult to foresee the technological capabilities that may allow reduction of greenhouse gas emissions by 2100.

Scenarios for future greenhouse gas amounts, especially for CO_2 and CH_4, are a major source of uncertainty for projections of future climate. Successive IPCC assessments over the past decade each have developed a new set of scenarios with little discussion of how well observed trends match with previous scenarios. The period of record is now long enough to make it useful to compare recent trends with the scenarios, and such studies will become all the more fruitful as years pass. The increase of global fossil fuel CO_2 emissions in the past decade, averaging 0.6% per year, has fallen below the IPCC scenarios. The growth of atmospheric CH_4 has fallen well below the IPCC scenarios. These slowdowns in growth rates could be short-term fluctuations that may be reversed. However, they

[1] Hansen, J., M. Sato, R. Ruedy, A. Lacis, and V. Oinas, Global warming in the twenty-first century: an alternative scenario, *Proceedings of the National*
Academy of Sciences, 97: 9875-9880, 2000.

emphasize the need to understand better the factors that influence current and future growth rates.

Global warming will not be spatially uniform, and it is expected to be accompanied by other climate changes. In areas and seasons in which there are large temperature changes, feedbacks may be much larger than their global values. An example of such regionally large effects is the ice-albedo feedback. Reduced snow cover and sea and lake ice will be important at high latitudes and higher elevations, especially during winter and spring. In the presence of the higher temperatures, atmospheric water vapor concentration and precipitation will also be higher. Determining the net ice-albedo feedback effect is complicated by its connections to other aspects of the hydrologic and energy cycles. Clouds may change to amplify or reduce its effect. Increased precipitation with warming at the margin of ice and snow may act to either reduce or amplify this effect, e.g., reducing the effect by increasing snow levels where it is below freezing. Changing vegetation cover likewise can introduce major modification.

An increase in the recycling rate of water in the hydrologic cycle is anticipated in response to higher global average temperatures. Higher evaporation rates will accelerate the drying of soils following rain events, thereby resulting in drier average conditions in some regions, especially during periods of dry weather during the warm season. The drier soils, with less water available for evapotranspiration, will warm more strongly during sunlight hours resulting in higher afternoon temperatures, faster evaporation, and an increase in the diurnal temperature range. The effect is likely to be greatest in semi-arid regions, such as the U.S. Great Plains. The faster recycling of water will lead to higher rainfall rates and an increase in the frequency of heavy precipitation events.

There is a possibility that global warming could change the behavior of one or more of the atmosphere's natural modes of

variability such as ENSO or the so-called North Atlantic or Arctic Oscillation. Such changes could lead to complex changes in the present-day patterns of temperature and precipitation, including changes in the frequency of winter or tropical storms. Higher precipitation rates would favor increased intensity of tropical cyclones, which derive their energy from the heat that is released when water vapor condenses.

Temperatures are expected to increase more rapidly over land compared to oceans because of the ocean's higher heat capacity and because it can transfer more of the trapped heat to the atmosphere by evaporation. Over land, the warming has been—and is expected to continue to be—larger during nighttime than during daytime.

Consequences of Increased Climate Change of Various Magnitudes

The U.S. National Assessment of Climate Change Impacts, augmented by a recent NRC report on climate and health, provides a basis for summarizing the potential consequences of climate change.[2] The National Assessment directly addresses the importance of climate change of various magnitudes by considering climate scenarios from two wellregarded models (the Hadley model of the United Kingdom and the Canadian Climate Model). These two models have very different globally-averaged temperature increases (2.7 and 4.4°C (4.9 and 7.9°F), respectively) by the year 2100. A key conclusion from the National Assessment is that U.S. society is likely to be

[2] Except where noted, this section is based on information provided in the U.S. National Assessment. U.S. Global Change Research Program, "Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change", 2001, Cambridge University Press, 612 pp.

able to adapt to most of the climate change impacts on human systems, but these adaptations may come with substantial cost. The primary conclusions from these reports are summarized for agriculture and forestry, water, human health, and coastal regions.

In the near term, agriculture and forestry are likely to benefit from CO_2 fertilization effects and the increased water efficiency of many plants at higher atmospheric CO_2 concentrations. Many crop distributions will change, thus requiring significant regional adaptations. Given their resource base, the Assessment concludes that such changes will be costlier for small farmers than for large corporate farms. However, the combination of the geographic and climatic breadth of the United States, possibly augmented by advances in genetics, increases the nation's robustness to climate change. These conclusions depend on the climate scenario, with hotter and drier conditions increasing the potential for declines in both agriculture and forestry. In addition, the response of insects and plant diseases to warming is poorly understood. On the regional scale and in the longer term, there is much more uncertainty.

Increased tendency toward drought, as projected by some models, is an important concern in every region of the United States even though it is unlikely to be realized everywhere in the nation. Decreased snow pack and/or earlier season melting are expected in response to warming because the freeze line will be moving to higher elevations. The western part of the nation is highly dependent on the amount of snow pack and the timing of the runoff. The noted increased rainfall rates have implications for pollution run-off, flood control, and changes to plant and animal habitat. Any significant climate change is likely to result in increased costs because the nation's investment in water supply infrastructure is largely tuned to the current climate.

Health outcomes in response to climate change are the

subject of intense debate. Climate change has the potential to influence the frequency and transmission of infectious disease, alter heat- and cold-related mortality and morbidity, and influence air and water quality. Climate change is just one of the factors that influence the frequency and transmission of infectious disease, and hence the assessments view such changes as highly uncertain.[3] This said, changes in the agents that transport infectious diseases (e.g., mosquitoes, ticks, rodents) are likely to occur with any significant change in precipitation and temperature. Increases in mean temperatures are expected to result in new record high temperatures and warm nights and an increase in the number of warm days compared to the present. Cold-related stress is likely to decline whereas heat stress in major urban areas is projected to increase if no adaptation occurs. The National Assessment ties increases in adverse air quality to higher temperatures and other air mass characteristics. However, much of the United States appears to be protected against many different adverse health outcomes related to climate change by a strong public health system, relatively high levels of public awareness, and a high standard of living. Children, the elderly, and the poor are considered to be the most vulnerable to adverse health outcomes. The understanding of the relationships between weather/climate and human health is in its infancy and therefore the health consequences of climate change are poorly understood. The costs, benefits, and availability of resources for adaptation are also uncertain.

Fifty-three percent of the U.S. population lives within the coastal regions, along with billions of dollars in associated infrastructure. Because of this, coastal areas are more vulnerable to increases in severe weather and sea level rise. Changes in storm frequency and intensity are one of the more

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[3] *Under the Weather: Climate, Ecosystems, and Infectious Disease*, 2001.

uncertain elements of future climate change prediction. However, sea level rise increases the potential damage to coastal regions even under conditions of current storm intensities and can endanger coastal ecosystems if human systems or other barriers limit the opportunities for migration.

In contrast to human systems, the U.S. National Assessment makes a strong case that ecosystems are the most vulnerable to the projected rate and magnitude of climate change, in part because the available adaptation options are very limited. Significant climate change will cause disruptions to many U.S. ecosystems, including wetlands, forests, grasslands, rivers, and lakes. Ecosystems have inherent value, and also supply the country with a wide variety of ecosystem services.

The impacts of these climate changes will be significant, but their nature and intensity will depend strongly on the region and timing of occurrence. At a national level, the direct economic impacts are likely to be modest. However, on a regional basis the level and extent of both beneficial and harmful impacts will grow. Some economic sectors may be transformed substantially and there may be significant regional transitions associated with shifts in agriculture and forestry. Increasingly, climate change impacts will have to be placed in the context of other stresses associated with land use and a wide variety of pollutants. The possibility of abrupt or unexpected changes could pose greater challenges for adaptation.

Even the mid-range scenarios considered in the IPCC result in temperatures that continue to increase well beyond the end of this century, suggesting that assessments that examine only the next 100 years may well underestimate the magnitude of the eventual impacts. For example a sustained and progressive drying of the land surface, if it occurred, would eventually lead to desertification of regions that are now marginally arable, and any substantial melting or breaking up of the Greenland and

Antarctic ice caps could cause widespread coastal inundation.[4]

"Safe" Level of Concentration of Greenhouse Gases

The potential for significant climate-induced impacts raises the question of whether there exists a "safe" level of greenhouse gas concentration. The word "safe" is ambiguous because it depends on both viewpoint and value judgment. This view changes dramatically if you are part of an Eskimo community dependent on sea ice for hunting, or an inhabitant of a coastal city, or a farm community. It depends on whether an industry is robust or sensitive to climate change. The viewpoint changes distinctly between countries with sufficient resources for adaptation and poorer nations. Value judgments become particularly important when assessing the potential impacts on natural ecosystems. The question can be approached from two perspectives. The first issue is whether there is a threshold in the concentration of greenhouse gases that, if exceeded, would cause dramatic or catastrophic changes to the Earth system. The second issue is whether the consequences of greenhouse warming, as a function of the concentration of greenhouse gases, are sufficiently well known that the scientific community can define "an acceptable concentration" based on an analysis of potential risks and damages. The first issue is best addressed by examining Earth's history. Guidance for the second issue can be derived from assessments of the impacts of climate change.

A variety of measurements demonstrate that CO_2 has varied substantially during Earth's history, reaching levels between

[4] Appreciable desertification on a regional scale could take place within a decade or two. Many centuries would be required for substantial melting of the ice sheets to occur and the likelihood of a breakup during this century is considered to be remote.

three and nine times pre-industrial levels of carbon dioxide prior to 50 million years ago. During the periods of hypothesized high carbon dioxide concentrations, there are strong indicators of warmth (although many different factors have contributed to climate change during Earth's history). These indicators include warm deep-sea temperatures and abundant life within the Arctic Circle. There are also some records of abrupt warming (thousands of years) in Earth's history that may be related to atmospheric greenhouse concentrations, which caused significant perturbations to the Earth system. The global temperature increases determined for some of these warm periods exceed future projections from all climate models for the next century. These changes are associated with some extinctions, and both the periods of warmth and abrupt transitions are associated with the large-scale redistribution of species. However, a substantial biosphere is evident (i.e., no catastrophic impact tending toward wholesale extinctions) even with substantially higher CO_2 concentrations than those postulated to occur in response to human activities.

The course of future climate change will depend on the nature of the climate forcing (e.g., the rate and magnitude of changes in greenhouse gases, aerosols) and the sensitivity of the climate system. Therefore, determination of an acceptable concentration of greenhouse gases depends on the ability to determine the sensitivity of the climate system as well as knowledge of the full range of the other forcing factors, and an assessment of the risks and vulnerabilities. Climate models reflect a range of climate sensitivities even with the same emission scenario. For example, the consequences of climate change would be quite different for a globallyaveraged warming of 1.1°C (2.0°F) or a 3.1°C (5.6°F) projected for the IPCC scenario in which CO_2 increases by 1% per year leading to a doubling from current levels in the next 70 years.

Both climate change and its consequences also are likely to have a strong regional character. The largest changes occur consistently in the regions of the middle to high latitudes. Whereas all models project global warming and global increases in precipitation, the sign of the precipitation projections varies among models for some regions.

The range of model sensitivities and the challenge of projecting the sign of the precipitation changes for some regions represent a substantial limitation in assessing climate impacts. Therefore, both the IPCC and the U.S. National Assessment of Climate Change Impacts assess potential climate impacts using approaches that are "scenario-driven." In other words, models with a range of climate sensitivities are used to assess the potential impacts on water, agriculture, human health, forestry, and the coastal zones, nationally and region by region. The differences among climate model projections are sufficiently large to limit the ability to define an "acceptable concentration" of atmospheric greenhouse gases. In addition, technological breakthroughs that could improve the capabilities to adapt are not known. Instead, the assessments provide a broader level of guidance:

• The nature of the potential impacts of climate change increases as a function of the sensitivity of the climate model. If globally-averaged temperature increases approach 3°C (5.4°F) in response to doubling of carbon dioxide, they are likely to have substantial impacts on human endeavors and on natural ecosystems.

• Given the fact that middle and high latitude regions appear to be more sensitive to climate change than other regions, significant impacts in these regions are likely to occur at lower levels of global warming.

• There could be significant regional impacts over the full range of IPCC model-based projections.

• Natural ecosystems are less able to adapt to change than are human systems.

In summary, critical factors in defining a "safe" concentration depend on the nature and level of societal vulnerability, the degree of risk aversion, ability and/or costs of adaptation and/or mitigation, and the valuation of ecosystems, as well as on the sensitivity of the Earth system to climate change.

7

Assessing Progress in Climate Science

What are the substantive differences between the IPCC Reports and the Summaries?

What are the specific areas of science that need to be studied further, in order of priority, to advance our understanding of climate change?

The committee was asked to address these two questions. The first involved evaluating the IPCC Working Group I report and summaries in order to identify how the summaries differ from the report. The second question involved characterizing areas of uncertainty in scientific knowledge concerning climate change, and identifying the research areas that will advance the understanding of climate change.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE

The full text of the IPCC Third Assessment Report on *The Scientific Basis* represents a valuable effort by U.S. and

international scientists in identifying and assessing much of the extensive research going on in climate science. The body of the WGI report is scientifically credible and is not unlike what would be produced by a comparable group of only U.S. scientists working with a similar set of emission scenarios, with perhaps some normal differences in scientific tone and emphasis.

However, because the IPCC reports are generally invoked as the authoritative basis for policy discussions on climate change, we should critically evaluate this effort so that we can offer suggestions for improvement. The goal is a stronger IPCC that will lead to better definitions of the nature of remaining problems, a clarity in expressing both robust conclusions and uncertainties, and thus aid achievement of the best possible policy decisions. We must also consider options for an improved process, given the enormous and growing investment required by individual scientists to produce this assessment. Three important issues directed to this goal are described below.

The IPCC Summary for Policy Makers

The IPCC WGI *Summary for Policymakers* (SPM) serves an obviously different purpose than the scientific working group reports. When one is condensing 1,000 pages into 20 pages with a different purpose in mind, we would expect the text to contain some modifications. After analysis, the committee finds that the conclusions presented in the SPM and the *Technical Summary* (TS) are consistent with the main body of the report. There are, however, differences. The primary differences reflect the manner in which uncertainties are communicated in the SPM. The SPM frequently uses terms (e.g., likely, very likely, unlikely) that convey levels of uncertainty; however, the text less frequently includes either

their basis or caveats. This difference is perhaps understandable in terms of a process in which the SPM attempts to underline the major areas of concern associated with a human-induced climate change. However, a thorough understanding of the uncertainties is essential to the development of good policy decisions.

Climate projections will always be far from perfect. Confidence limits and probabilistic information, with their basis, should always be considered as an integral part of the information that climate scientists provide to policy and decision makers. Without them, the IPCC SPM could give an impression that the science of global warming is "settled," even though many uncertainties still remain. The emission scenarios used by the IPCC provide a good example. Human decisions will almost certainly alter emissions over the next century. Because we cannot predict either the course of human populations, technology, or societal transitions with any clarity, the actual greenhouse gas emissions could be either greater or less than the IPCC scenarios. Without an understanding of the sources and degree of uncertainty, decision makers could fail to define the best ways to deal with the serious issue of global warming.

Modification of the Scientific Text After Completion of the SPM

The SPM results from a discussion between the lead authors and government representatives (including also some non-governmental organizations and industry representatives). This discussion, combined with the requirement for consistency, results in some modifications of the text, all of which were carefully documented by the IPCC. This process has resulted in some concern that the scientific basis for the SPM might be altered. To assess this potential problem, the committee

solicited written responses from U.S. coordinating lead authors and lead authors of IPCC chapters, reviewed the WGI draft report and summaries, and interviewed Dr. Daniel Albritton who served as a coordinating lead author for the IPCC WGI *Technical Summary*. Based on this analysis, the committee finds that no changes were made without the consent of the convening lead authors and that most changes that did occur lacked significant impact. However, some scientists may find fault with some of the technical details, especially if they appear to underestimate uncertainty. The SPM is accompanied by the more representative *Technical Summary* (TS). The SPM contains cross-references to the full text, which unfortunately is not accessible until a later date, but it does not cross-reference the accompanying TS.

The IPCC as Representative of the Science Community

The IPCC process demands a significant time commitment by members of the scientific community. As a result, many climate scientists in the United States and elsewhere choose not to participate at the level of a lead author even after being invited. Some take on less time-consuming roles as contributing authors or reviewers. Others choose not to participate. This may present a potential problem for the future. As the commitment to the assessment process continues to grow, this could create a form of self-selection for the participants. In such a case, the community of world climate scientists may develop cadres with particularly strong feelings about the outcome: some as favorable to the IPCC and its procedures and others negative about the use of the IPCC as a policy instrument. Alternative procedures are needed to ensure that participation in the work of the IPCC does not come at the expense of an individual's scientific career.

In addition, the preparation of the SPM involves both

scientists and governmental representatives. Governmental representatives are more likely to be tied to specific government postures with regard to treaties, emission controls, and other policy instruments. If scientific participation in the future becomes less representative and governmental representatives are tied to specific postures, then there is a risk that future IPCC efforts will not be viewed as independent processes.

The United States should promote actions that improve the IPCC process while also ensuring that its strengths are maintained. The most valuable contribution U.S. scientists can make is to continually question basic assumptions and conclusions, promote clear and careful appraisal and presentation of the uncertainties about climate change as well as those areas in which science is leading to robust conclusions, and work toward a significant improvement in the ability to project the future. In the process, we will better define the nature of the problems and ensure that the best possible information is available for policy makers.

RESEARCH PRIORITIES

The underlying scientific issues that have been discussed in this report and the research priorities that they define have evolved over time. For this reason, many have been identified previously in NRC reports.[1]

Predictions of global climate change will require major advances in understanding and modeling of (1) the factors that

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[1] *Decade-to-Century-Scale Climate Variability and Change: A Science Strategy*, 1998; *The Atmospheric Sciences Entering the Twenty-First Century*, 1998; *Adequacy of Climate Observing Systems*, 1999; *Global Environmental Change: Research Pathways for the Next Decade*, 1999; *Improving the Effectiveness of U.S. Climate Modeling*, 2001; *The Science of Regional and Global Change: Putting Knowledge to Work*, 2001.

determine atmospheric concentrations of greenhouse gases and aerosols and (2) the so called “feedbacks” that determine the sensitivity of the climate system to a prescribed increase in greenhouse gases. Specifically, this will involve reducing uncertainty regarding: (a) future usage of fossil fuels, (b) future emissions of methane, (c) the fraction of the future fossil fuel carbon that will remain in the atmosphere and provide radiative forcing versus exchange with the oceans or net exchange with the land biosphere, (d) the feedbacks in the climate system that determine both the magnitude of the change and the rate of energy uptake by the oceans, which together determine the magnitude and time history of the temperature increases for a given radiative forcing, (e) the details of the regional and local climate change consequent to an overall level of global climate change, (f) the nature and causes of the natural variability of climate and its interactions with forced changes, and (g) the direct and indirect effects of the changing distributions of aerosol. Because the total change in radiative forcing from other greenhouse gases over the last century has been nearly as large as that of carbon dioxide, their future evolution also must be addressed. At the heart of this is basic research, which allows for creative discoveries about those elements of the climate system that have not yet been identified, or studied.

Knowledge of the climate system and projections about the future climate are derived from fundamental physics and chemistry through models and observations of the atmosphere and the climate system. Climate models are built using the best scientific knowledge of the processes that operate within the climate system, which in turn are based on observations of these systems. A major limitation of these model forecasts for use around the world is the paucity of data available to evaluate the ability of coupled models to simulate important aspects of past climate. In addition, the observing system available today is a composite of observations that neither provide the

information nor the continuity in the data needed to support measurements of climate variables. Therefore, above all, it is essential to ensure the existence of a long-term observing system that provides a more definitive observational foundation to evaluate decadal- to century-scale variability and change. This observing system must include observations of key state variables such as temperature, precipitation, humidity, pressure, clouds, sea ice and snow cover, sea level, sea-surface temperature, carbon fluxes and soil moisture. Additionally, more comprehensive regional measurements of greenhouse gases would provide critical information about their local and regional source strengths.

Climate observations and modeling are becoming increasingly important for a wide segment of society including water resource managers, public health officials, agribusinesses, energy providers, forest managers, insurance companies, and city planners. In order to address the consequences of climate change and better serve the nation's decision makers, the research enterprise dealing with environmental change and environment-society interactions must be enhanced. This includes support of (a) interdisciplinary research that couples physical, chemical, biological, and human systems, (b) improved capability of integrate scientific knowledge, including its uncertainty, into effective decision support systems, and (c) an ability to conduct research at the regional or sectoral level that promotes analysis of the response of human and natural systems to multiple stresses.

Climate research is presently overseen by the U.S. Global Change Research Program (USGCRP). A number of NRC reports[2] have concluded that this collection of agencies is

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[2] *Global Environmental Change: Research Pathways for the Next Decade*, 1999; *Improving the Effectiveness of U.S. Climate Modeling*, 2001; *The Science of Regional and Global Change: Putting Knowledge to Work*, (continued...)

hampered organizationally in its ability to address the major climate problems. The ability of the United States to assess future climate change is severely limited by the lack of a climate observing system, by inadequate computational resources, and by the general inability of government to focus resources on climate problems. Efforts are needed to ensure that U.S. efforts in climate research are supported and managed to ensure innovation, effectiveness, and efficiency. These issues have been addressed by NRC reports, but more examination is needed.

[2] (...continued)
2001.

Appendixes
A
Letter from the White House

THE WHITE HOUSE
WASHINGTON

May 11, 2001

Dr. Bruce Alberts
National Academy of Sciences
2101 Constitution Avenue, NW
Washington, D.C. 20418

Dear Dr. Alberts:

The Administration is conducting a review of U.S. policy on climate change. We seek the Academy's assistance in identifying the areas in the science of climate change where there are the greatest certainties and uncertainties.

We would like your views on whether there are any substantive differences between the IPCC Reports and the IPCC summaries.

We would appreciate a response as soon as possible.

Sincerely yours,

/s/ John M. Bridgeland
Deputy Assistant to the President for Domestic Policy and Director, Domestic Policy Council

/s/ Gary Edson
Deputy Assistant to the President for International Economic Affairs

B

Biographical Sketches of Committee Members and Staff

Dr. Ralph J. Cicerone *(Chair)* is the chancellor of the University of California at Irvine and the Daniel G. Aldrich Professor in the Department of Earth System Science and the Department of Chemistry. His areas of research include atmospheric chemistry; sources of gases that affect climate and the composition of the global atmosphere, especially methane and nitrous oxide; and the ozone layer and human influence on it. He is a member of the National Academy of Sciences. Dr. Cicerone received his Ph.D. from the University of Illinois.

Dr. Eric J. Barron is Director of the Earth and Mineral Sciences Environment Institute and Distinguished Professor of Geosciences at Pennsylvania State University. His specialty is paleoclimatology/paleoceanography. His research emphasizes global change, specifically numerical models of the climate system and the study of climate change throughout Earth's history. Dr. Barron is a fellow of the American Geophysical Union and the American Meteorological Society. He has served on several National Research Council committees, including, most recently, the Grand Challenges in the Environmental Sciences and the Task Group on Assessment of NASA Plans for Post-2000 Earth Observing Missions. He is currently the chair of the Board on Atmospheric Sciences and Climate. Dr. Barron received his Ph.D. from the University of Miami.

Dr. Robert E. Dickinson is a professor of dynamics and climate in the School of Earth and Atmospheric Sciences at the Georgia Institute of Technology. His research interests include the dynamics of atmospheric planetary waves, stratospheric

dynamics, models of global structure and dynamics of terrestrial and planetary thermosphere, NLTE infrared radiative transfer in planetary mesopheres, global climate modeling and processes, the role of land processes in climate systems, the modeling role of vegetation in regional evapotranspiration, and the role of tropical forests in climate systems. Dr. Dickinson is a member of the National Academy of Sciences and the recipient of the Revelle medal of the American Geophysical Union (AGU) and the Rossby award of the American Meteorological Society. He is currently president-elect of the AGU. Dr. Dickinson received his Ph.D. from the Massachusetts Institute of Technology.

Dr. Inez Y. Fung is the Richard and Rhoda Goldman Distinguished Professor for the Physical Sciences, Director of the Center for Atmospheric Sciences, and a professor in the Department of Earth and Planetary Science and the Department of Environmental Sciences, Policy and Management at the University of California at Berkeley. Her research expertise is in large-scale numerical modeling of biogeochemical cycles and their interaction with climate. Her research also includes climate change, remote sensing of earth systems, investigations of atmosphere-ocean interactions, and atmosphere-biosphere interactions. She is a member of the National Academy of Sciences, a fellow of the American Geophysical Union and the American Meteorological Society, and a recipient of NASA's Exceptional Scientific Achievement Medal. Dr. Fung received her Sc.D. from the Massachusetts Institute of Technology.

Dr. James E. Hansen is head of the NASA Goddard Institute for Space Studies. His research interests include radiative transfer in planetary atmospheres, interpretation of remote sounding of planetary atmospheres, development of simplified climate models and three-dimensional global climate models,

current climate trends from observational data, and projections of man's impact on climate. He is a member of the National Academy of Sciences and a fellow of the American Geophysical Union. Dr. Hansen received his Ph.D. from the University of Iowa.

Mr. Thomas R. Karl is Director of the National Climatic Data Center of the National Oceanic and Atmospheric Administration. Before this he served as the senior scientist where his research interests included global climate change, extreme weather events, and trends in global and U.S. climate over the past 100 years. Mr. Karl is a fellow of the American Meteorological Society and the American Geophysical Union and served as the chair of the National Research Council's Climate Research Committee. He was a coordinating lead author for the IPCC Working Group I Third Assessment Report. Mr. Karl received his M.S. from the University of Wisconsin.

Dr. Richard S. Lindzen is the Alfred P. Sloan Professor of Meteorology in the Department of Earth, Atmospheric and Planetary Sciences at the Massachusetts Institute of Technology. His research interests include dynamic meteorology and climatology, specifically upper atmosphere dynamics, waves and instability, climate sensitivity, regional and interannual variability of weather, tropical meteorology, monsoons, mesoscale systems, clear air turbulence, climate dynamics, and general circulation. He is a member of the National Academy of Sciences and a fellow of the American Association for the Advancement of Science. He was a lead author for the IPCC Working Group I Third Assessment Report. Dr. Lindzen received his Ph.D. from Harvard University.

Dr. James C. McWilliams is the Slichter Professor of Earth Sciences in the Department of Atmospheric Sciences and the Institute for Geophysics and Planetary Physics at the University of California at Los Angeles. His research focuses on the fluid dynamics of Earth's oceans and atmosphere, both their theory and computational modeling. Particular subjects of interest include the maintenance of general circulations; climate dynamics; geostrophically and cyclo-strophically balanced dynamics in rotating, stratified fluids; vortex dynamics; the planetary boundary layers; planetary- scale thermohaline convection, the roles of coherent structures of turbulent flows in geophysical and astrophysical regimes; numerical methods; coastal ocean modeling and statistical estimation theory. He is a fellow of the American Geophysical Union and has served on the National Research Council's Climate Research Committee and Board on Atmospheric and Sciences. Dr. McWilliams received his Ph.D. from Harvard University.

Dr. F. Sherwood Rowland is the Donald Bren Research Professor of Chemistry and Earth System Science at the University of California at Irvine. His research interests include atmospheric chemistry (stratospheric ozone, trace compounds in the troposphere on a global basis); chemical kinetics, in particular, gas phase reactions of chlorine, fluorine, and hydrogen; and radiochemistry, specifically tracer studies with radioactive isotopes. Dr. Rowland is a member of the National Academy of Sciences where he currently serves as Foreign Secretary. He is also a member of the Institute of Medicine. He has received numerous awards including the Nobel Prize in Chemistry in 1995 and the Revelle medal of the American Geophysical Union. Dr. Rowland received his Ph.D. from the University of Chicago.

Dr. Edward S. Sarachik is a professor in the Department of

Atmospheric Sciences and an adjunct professor in the School of Oceanography at the University of Washington. His research interests focus on large-scale atmosphere-ocean interactions, seasonal variations in the tropical oceans, the role of the ocean in climate change, and biogeochemical cycles in the global ocean. Dr. Sarachik is a fellow of the American Geophysical Union, the American Meteorological Society, and the American Association for the Advancement of Science. He has served on numerous National Research Council committees including the Climate Research Committee, the Tropical Ocean/Global Atmosphere (TOGA) Advisory Panel (chair), and the Panel on Improving U.S. Climate Modeling (chair). Dr. Sarachik received his Ph.D. from Brandeis University.

Dr. John M. Wallace is a professor of atmospheric sciences and co-director of the University of Washington Program on the Environment. From 1981-98 he served as director of the (University of Washington/NOAA) Joint Institute for the Study of the Atmosphere and the Ocean. His research specialties include the study of atmospheric general circulation, El Niño, and global climate. He is a member of the National Academy of Sciences; a fellow of the American Association for the Advancement of Science, the American Geophysical Union (AGU), and the American Meteorological Society (AMS); and the recipient of the Rossby medal of the AMS and Revelle medal of the AGU. Dr. Wallace received his Ph.D. from the Massachusetts Institute of Technology.

Dr. Vaughan C. Turekian *(Study Director)* is a Program Officer with the Board on Atmospheric Sciences and Climate. He received his B.S. from Yale University, where he specialized in Geology and Geophysics and International Studies. He received his Ph.D. in Environmental Sciences from the University of Virginia in 2000 where he used stable bulk

and compound-specific isotope analyses to characterize the sources and processing of aerosols in marine air.

UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

COMMONWEALTH OF MASSACHUSETTS, et al.,	)	
Petitioners,	)	
v.	)	No. 03-1361
	)	Consolidated with
UNITED STATES ENVIRONMENTAL PROTECTION AGENCY,	)	Nos. 03-1362-1368
Respondent.	)	

DECLARATION OF MICHAEL C. MacCRACKEN

I, MICHAEL C. MacCRACKEN, declare as follows:

1. I received my Bachelor's of Science in Mechanical Engineering from Princeton University in 1964. I then received my Master of Science and Ph.D. degrees in Applied Science from the University of California Davis in 1966 and 1968, respectively. I was elected to the Phi Kappa Phi honorary society at both undergraduate and graduate levels. From 1968 to 2002, I was employed as a physicist at the University of California's Lawrence Livermore National Laboratory (LLNL), where I led a number of scientific projects using numerical models to simulate the effects of transport and industrial emissions on air quality and the response of the climate to a range of natural and human-induced perturbations, including the likely impacts of an increase in the concentrations of greenhouse gases such as carbon dioxide. As a result of these projects, I am the co-author/co-editor of eight books, 22 journal

articles, and hundreds of other reports and other notes.

2. From 1993 to 2002, I was on assignment from my permanent position with LLNL to serve as the senior scientist on global change at the Office of the U. S. Global Change Research Program. In this capacity, I served as the first Executive Director of the Office of the U.S. Global Change Research Program ("USGCRP") from 1993-1997. I was responsible for assisting in the coordination of the global change research programs of ten federal agencies, including the Environmental Protection Agency, the Department of Energy, the National Science Foundation, the National Oceanographic and Atmospheric Administration, NASA, and others. In addition, in my role as senior scientist, I was responsible for keeping up with scientific advances in the field for the USGCRP and assisting the Office of Science and Technology Policy (OSTP) of the Executive Office of the President in summarizing the scientific advances for government leaders.

3. Following my tenure as Executive Director of the Office of the USGCRP, I was appointed Executive Director of the National Assessment Coordination Office, and served from 1997 through 2001 in this role. I led a small staff that had responsibility for coordinating the U.S. National Assessment of the Potential Consequences of Climate Variability and Change (U.S. National Assessment), which was carried out under the auspices of the USGCRP. This responsibility included helping to design and support the overall assessment activity, focusing particularly on ensuring the high quality of the scientific aspects. The U. S. National Assessment was carried out at the direction of the Director of OSTP. The National Assessment brought together the efforts of 20 university-based regional teams, 5 joint university-government scientific teams focused on particular sectors of the economy and natural resources, and a federal advisory committee composed of 12 leading scientists

and experts. In addition to participating in and reviewing many of the regional and sectoral activities and reports, I served as an additional lead author and generally contributed to the preparation of the national level reports entitled *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change*, that were published in 2000 and 2001.[1] I was an additional lead author of the National Assessment's Overview Report, and for the National Assessment's Foundation Report I was one of the lead authors of "Chapter 1: Scenarios for Climate Variability and Change" and "Chapter 12: Potential Consequences of Climate Variability and Change for Native Peoples and Homelands." In my role as Executive Director of the National Assessment Coordination Office, I also prepared Chapter 6 of the U.S. Government's *Climate Action Report 2002*.[2] This report was the U.S. Government's quadrennial national communication under the United Nations Framework Convention on Climate Change; Chapter 6, on impacts and adaptation, incorporated the findings of the National Assessment. In 2002-03, I also assisted the Department of Transportation in the conduct of a workshop on the potential impacts of climate change on transportation.

4. I have served in various capacities in the preparation of the First, Second and Third Assessments of the Intergovernmental Panel on Climate Change (IPCC). For the IPCC's First Assessment Report, which was completed in 1990, I was a contributor to Chapter 5 on "Equilibrium Climate

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[1] U.S. Global Change Research Program, *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change: Overview Report* (2000) and *Foundation Report* (2001). Available from Cambridge University Press.

[2] U.S. Dept. of State, *U.S. Climate Action Report 2002* (U.S. Government Printing Office 2002).

Change—and its Implications for the Future" and Chapter 8 on "Detection of the Greenhouse Effect in the Observations." For the Second Assessment, which was completed in 1995, I was a contributor to Chapter 8 of Working Group I, "Detection of Climate Change and Attribution of Causes," and a lead author of Chapter 25 of Working Group II, "Mitigation: Cross-Sectoral and Other Issues." For the Third Assessment that was completed in 2001, I was a contributing author to Chapter 12 of Working Group I, "Detection of Climate Change and Attribution of Causes." I was a reviewer of various chapters for each of these assessment reports and as part of my responsibility for the Office of the U.S. Global Change Research Program, I served as scientific coordinator for the official reviews of the U.S. Government for both the Working Group I and II contributions for the Second and Third IPCC Assessment Reports. I also served as scientific advisor to the U.S. delegation at the plenary meetings of Working Group I for the Second and Third Assessments,[3] contributing to the preparation of the Summary for Policymakers of each assessment. For the IPCC's Fourth Assessment Report to be completed in 2007, I was recently appointed by the leadership of Working Group II to serve as Review Editor for Chapter 14, which will focus on past, ongoing, and future impacts of climate change on North America.

[3] Held in Madrid, Spain in November 1995 and in Shanghai, China in January 2001. Prior to joining the Office of the USGCRP, I also served as a scientific adviser to the US delegation for consideration of the IPCC Working Group I special report in January 1992 held in Guangzhou, China.

Summary of Opinions

5. The following findings and supporting information are offered as my expert scientific opinion, based on my education, qualifications, experience, and knowledge of the relevant scientific literature. These findings, in my expert opinion, also reflect the strong consensus of opinion among qualified scientific experts involved in climate change research in the U.S. and around the world:

a. The atmospheric concentrations of three important greenhouse gases, namely carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), have been increasing since about 1750 as a result of human activities, principally the combustion of fossil fuel. The higher concentrations of these greenhouse gases enhance the Earth's natural greenhouse effect and exert a warming influence on the Earth's climate. The human-induced increases in the concentrations of CO_2, CH_4, and N_2O are widely considered to be the major factor responsible for the global warming of about 0.6˚C (about 1˚F) that occurred during the 20th century.

b. The most probable scenarios of future greenhouse gas emissions indicate that, in the absence of policy change, atmospheric concentrations of greenhouse gases will continue to rise steadily throughout this century, very likely exceeding concentrations seen over at least the last 10 million years. As a result, global average surface air temperature, which has already increased by about 0.6˚C (about 1˚F) over the last century, will also continue rising at rates unprecedented in human history. In its Third Assessment Report, averaging across the results of climate models, the IPCC concluded that global surface air temperature is likely to increase by about 0.2 to 0.5˚C (about 0.3 to 0.9˚F) per decade. By the end of the century, global average surface air temperature is projected to

increase by about 2 to 4.5˚C over 1990 levels.

c. Important environmental impacts of global warming that have occurred to date include: (i) the warming of the oceans and the increased melting of many mountain glaciers around the world that were the major contributions to the rise in global sea level by 10-20 cm (4 to 8 inches) observed over the past century; (ii) the lengthening of the growing season in mid- and high-latitudes that has contributed to poleward and altitudinal shifts of plant and animal ranges and the declines of some plant and animal populations; and (iii) the thawing of permafrost, and the later freezing and earlier break-up of ice on rivers and lakes.[4]

d. The environmental impacts of projected global warming will include: (i) an increase in sea level at an average rate of about 0.5 to 3.5 inches per decade, reaching 4-35 inches by the end of the century (with the most likely value being, in my expert opinion, near or above the middle of this range); (ii) severe and irreversible changes to important natural ecosystems (e.g., coral reefs, Arctic coastal environments) and geographic features (e.g., forest boundaries, glaciers and ice sheets); and (iii) significant reduction of water storage in winter snowpack in mountainous regions with direct and important economic consequences;

e. Achievable reductions in emissions of CO_2 and other greenhouse gases from U.S. motor vehicles would significantly reduce the build-up in atmospheric concentrations of these gases and delay and moderate many

[4] Some text is drawn from the IPCC's Third Assessment Report *Climate Change 2001: Impacts, Adaptation and Vulnerability*; Cambridge University Press, page 3.

of the adverse impacts of global warming.

The scientific basis for each of these findings is explained in more detail below.

Current State of Scientific Authority on Climate Change

6. Collective scientific understanding of climate change is best represented in major assessment reports that assemble, evaluate and critically summarize the results of thousands of scientific papers and studies that have been written about the many aspects of the climate change issue. These carefully peer reviewed assessment reports present the most authoritative consensus available of the scientific understanding of the effects of human activities on climate, as well as of the potential impacts of climate change on the world and the U.S.

7. In the late 1980s, the international community formed the Intergovernmental Panel on Climate Change (IPCC), which produced a series of major assessments of climate change in 1990, 1995 and 2001.[5] The national academies of science of

[5] The IPCC's First Assessment Report series in 1990 consisted of the following reports: *Scientific Assessment of Climate Change — Report of Working Group I* (Cambridge University Press, UK); *Impacts Assessment of Climate Change — Report of Working Group II* (Australian Government Publishing Service Marketing Section); and *The IPCC Response Strategies — Report of Working Group III* (Island Press, USA). The IPCC's Second Assessment Report Series in 1995 consisted of the following: *Climate Change 1995: The Science of Climate Change*; *Climate Change 1995: Impacts, Adaptations and Mitigation of Climate Change: Scientific-Technical Analyses*; and *Climate Change 1995: Economic and Social Dimensions of Climate Change* (all available from Cambridge University Press). The IPCC's Third Assessment Report series in 2001 consisted of the following: *Climate Change 2001: Synthesis Report; Climate Change 2001*: *The Scientific Basis* (Houghton et al. eds., Cambridge Univ. Press 2001) (available at http://www.grida.no/climate/ipcc_tar/wg1/index.htm) ("Working Group I report"); *Climate Change 2001: Impacts, Adaptation and* (continued...)

approximately twenty nations, including the U.S.,[6] recognize the IPCC's 2001 findings as the most authoritative available concerning human-induced changes in climate and associated consequences. As a result of my involvement in the development of these assessments, as summarized in paragraph 4, I have an extensive understanding of the findings of the IPCC reports relating to climate change science and consequent impacts, especially as they relate to the United States.

8. The National Assessment of the Potential Consequences of Climate Variability and Change, undertaken by the U.S. Global Change Research Program (USGCRP) pursuant to Section 106 of the Global Change Research Act of 1990 [Public Law 101-606], is the major assessment most directly focused on the potential impacts of climate change for the United States.[7] As a result of my role as an author and as Executive Director of the office responsible for coordinating preparation of the National Assessment (see paragraph 3), I have a detailed knowledge of the findings of the National Assessment.

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[5] (...continued)
Vulnerability (McCarthy et al. eds., Cambridge Univ. Press 2001) (available at http://www.grida.no/climate/ipcc_tar/wg2/) ("Working Group II report"); and *Climate Change 2001: Mitigation* (Pachauri et al. eds., Cambridge Univ. Press 2001) (available at http://www.grida.no/climate/ipcc_tar/wg3/index.htm) ("Working Group III report"). In addition, the IPCC has published many other special reports and documents. See http://www.ipcc.ch/pub/reports.htm.

[6] Natl. Research Council, *Climate Change Science: An Analysis of Some Key Questions* (Natl. Academies Press 2001).

[7] U. S. Global Change Research Program, *Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change: Overview Report* (2000) and *Foundation Report* (2001). Both reports are available from Cambridge University Press.

9. The U.S. Government also included the findings of the National Assessment in its *Climate Action Report 2002*, the U.S. Government's quadrennial national communication under the United Nations Framework Convention on Climate Change.[8] I prepared Chapter 6 of this report, on impacts and adaptation, in my capacity as Executive Director of the National Assessment Coordination Office of the USGCRP. It is in full agreement with the presentation of the science and impacts contained in the IPCC and National Assessment reports.

10. The IPCC and NAST assessments carefully indicate the level of confidence and uncertainty that can be associated with the various dimensions of the issue. For example, the IPCC's Third Assessment Report adopted a specific set of terms to address the degree of certainty associated with various findings, with a numerical range of likelihood associated with each term: "In this Summary for Policymakers and in the Technical Summary, the following words have been used where appropriate to indicate judgmental estimates of confidence: *virtually certain* (greater than 99% chance that a result is true); *very likely* (90-99% chance); *likely* (66-90%); *medium likelihood* (33-66% chance); *unlikely* (10-33% chance); *very unlikely* (1-10% chance); *exceptionally unlikely* (less than 1% chance)."[9] For the U.S. National Assessment, NAST developed a similar lexicon: very likely or very probable, likely or probable, possible, unlikely or some chance, and very unlikely or little chance. My use of these terms in the following paragraphs is consistent with this IPCC and NAST usage.

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[8] U.S. Dept. of State, *U.S. Climate Action Report 2002* (U.S. Government Printing Office 2002).

[9] IPCC Working Group I report, 2004, page 2, footnote 7 [italics in original].

The Role of Greenhouse Gases in Global Warming

11. Greenhouse gases in the atmosphere absorb about 90% of the solar energy that is radiated upward from the Earth's surface, and then these greenhouse gases re-radiate much of the energy back down to the surface. In this way, the greenhouse gases act in a manner roughly equivalent to adding a blanket over the Earth. The higher the concentrations of greenhouse gases, especially CO_2, CH_4, and N_2O, the greater will be the trapping of heat and the increase in surface temperature.

Man-Made Increases in Greenhouse Gas Concentrations and Resulting Global Warming

12. The concentration of CO_2 in the air has increased from about 278 ppmv (about 0.028%) to over 370 ppmv[10] since the start of the Industrial Revolution.[11] Methane (CH_4) concentrations have increased from about 0.7 ppmv in 1750 to about 1.745 ppmv today, and nitrous oxide (N_2O) concentrations have increased from about 0.27 ppmv in 1750 to over 0.314 ppmv today. The concentrations of hydrofluorocarbons (a man-made compound invented only in the last century) are also increasing.[12]

13. The increase in greenhouse gas concentrations is very likely the dominant cause of the increase in average global surface temperatures of approximately 0.6˚C during the 20th century. Evidence of global-scale warming over this period is also found in the unusually strong retreat of mountain glaciers

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[10] NOAA recently reported that the peak monthly value of the CO_2 concentration had reached over 375 ppmv.

[11] The abbreviation "ppmv" stands for parts per million by volume, which is equivalent to saying the number of molecules in the atmosphere of a given substance for every million molecules of dry air.

[12] *See* IPCC, Working Group I report, 2004, at page 358.

in many areas of the world, faster rate of rise of sea level as compared to before the 20th century (as a result of both glacial meltwater flowing into the oceans and heating-induced thermal expansion of the ocean waters), increases in the amount of moisture in the atmosphere and in the share of total precipitation occurring during intense rainfall events, and geographic shifts in the ranges of various plants and animals that are largely consistent with human-induced shifts in the climate. Each of these changes is indicative of global-scale warming and associated changes in climate since the mid-19th century, and all are occurring simultaneously.

14. Natural influences alone cannot explain the very sharp warming of the late 20th century. If solar irradiance has been changing at all, it has been decreasing during the second half of the 20th century, and the record of volcanic eruptions indicates that they have also likely induced a cooling influence over the past 50 years—so the two most important natural influences would have tended to cool the Earth just when it was in fact warming rapidly. The warming has also been larger than could be explained by past natural oscillations in the climate since the end of the last glaciation about 10,000 years ago.

Projections of Changes in Greenhouse Gas Emissions Over the 21st Century

15. Reliable projections of future changes in the climate are most effectively carried out using: (a) climate models that ensure objective and quantitative consideration is given to all relevant processes and factors governing the behavior of the climate system, and (b) emissions scenarios that are based upon the best available projections of how population, economic development, and energy technologies are expected to evolve.

16. Absent changes in policy to reduce greenhouse gas emissions, atmospheric concentrations of these gases are likely

to increase at least as much and at least as fast as in recent decades. I base this opinion on internationally accepted quantitative scenarios generated by the IPCC.[13] These scenarios cover a wide range of possible outcomes from now until the end of the 21st century in terms of global population growth, economic development, and energy technologies and rates of use.

17. If annual global emissions of greenhouse gases continue to increase in the next several decades in accordance with these scenarios, there will be significant increases in the atmospheric concentrations of these gases. Under the most plausible energy scenarios, the CO_2 concentration will continue to increase over the coming decades, reaching between two to three times its preindustrial level by the end of this century (for reference, the current concentration is approximately 1.35 times the preindustrial concentration).

Future Global Warming

18. These increases in concentrations will likely accelerate the rate of warming. In its Third Assessment Report, averaging across the results of climate models, the IPCC concluded that global surface air temperature is likely to increase by about 0.2 to 0.5˚C (about 0.3 to 0.9˚F) per decade. By the end of the century, global average surface air temperature is projected to increase by about 2 to 4.5˚C over 1990 levels. These are projections for changes in the global average surface temperature. Temperature changes over land areas are expected to be greater than over the ocean and temperature changes in mid to high latitudes are expected to exceed changes in low latitudes. Because of this, the IPCC's projection of regional temperature changes indicates larger changes are likely over

[13] IPCC, *Emissions Scenarios*, 2000 (Cambridge Univ. Press 2000) (avail. at http://www.ipcc.ch/pub/sres-e.pdf).

North America. Warming in the Arctic is projected to be even greater.[14]

19. Overall, this projected temperature increase would be likely to make average conditions by the end of this century warmer than they have been for at least 420,000 years (the period for which ice core data is available).

The Consequences of Future Global Warming

20. This projected temperature increase would have widespread adverse consequences.[15] For the U.S., the National Assessment summarizes key findings for different regions of the country and for different national sectors.[16] The following enumeration of conditions focuses mainly on consequences related to human health and the services provided by ecosystems and landscapes within the U.S.

21. ***Increased incidence of high temperatures and extremely high heat index:*** The climate scenarios considered in the U.S. National Assessment were based primarily on model simulations done by two IPCC-accepted models, each running a mid-range scenario for future emissions. These models projected an annual average warming of about 3 to 5˚C (about

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[14] IPCC Working Group I report, 2004, at chapter 10.

[15] See IPCC's Third Assessment Report *Climate Change 2001: Impacts, Adaptation and Vulnerability* (McCarthy et al. eds., Cambridge Univ. Press 2001) (available at http://www.grida.no/climate/ipcc_tar/wg2/) ("Working Group II report"). In addition, a database of articles on the likely impacts of climate change for the U.S. and other countries is available at <http://www.climate.org/CI/index.shtml>.

[16] National Assessment Synthesis Team, U.S. Global Change Research Program, *Climate Change Impacts on the United States, Overview* (Cambridge Univ. Press 2000) and *Foundation* (Cambridge Univ. Press 2001) (these reports and supporting regional and sectoral reports are available at <http://www.usgcrp.gov/usgcrp/nacc/default.htm>).

5 to 9˚F) across the U.S. during this century, which would be several times the increase across the U.S. during the 20th century.[17] The change in summertime temperatures, combined with the associated increase in absolute humidity, is projected to cause the 24-hour average heat index (a combined measure of temperature and humidity) for July (as a representative summer month) to increase by at least 6˚C (about 10˚F) over most of the country by 2100. Changes are projected to be about double this amount in some regions, particularly across the southeastern and south-central U.S. where the summertime heat index is already high. In addition to such changes in the monthly average temperature, the models also project that the length of the very warm season will increase and the occurrence of very high heat index conditions will be expected to be more frequent in more northerly parts of the country where people are not well adapted to such conditions.

22. ***Air quality is likely to be further impaired:*** Without additional control measures, ongoing and projected changes in climate due to global warming are very likely to increase emissions of various pollutants.[18] Higher temperatures caused

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[17] MacCracken et al., Climate change scenarios for the U.S. National Assessment, **84** *Bulletin of the American Meteorological Society*, 1711 (2003) (<avail. at http://ams.allenpress.com/pdfserv/i1520-0477-084-12-1711.pdf>).

[18] For example, warmer temperature will increase demand for energy (in buildings, cars, etc.) while decreasing the efficiency of combustion processes (in generating plants and in internal combustion engines), leading to the emission of more pollutants; warmer temperatures will increase the release of smog-forming hydrocarbons from oil storage tanks and other storage containers and from forests and vegetation; the increased CO_2 concentration is expected to enhance growth of biomass, which could in some regions provide a larger source of hydrocarbon emissions; warmer temperatures will tend to increase the summertime drying of biomass, making the increased biomass into a larger fuel base for fires and the pollutants that they emit.

by global warming will increase the rates of the photochemical reactions that convert smog-forming emissions (volatile organic compounds and oxides of nitrogen) into ozone smog.[19] In addition, unless there is a substantial and compensating tightening of emissions standards on all types of sources, longer warm seasons are very likely to increase the frequency of high ozone concentration episodes and violations of air quality standards.

23. ***Projected warming will also cause significant sea level rise:*** Global warming contributed significantly to the 10 to 20 cm (about 4 to 8 inches) rise in sea level during the 20th century. The meltback of mountain glaciers and warming of the oceans will contribute even more significantly to future sea level rise. The IPCC assessment projects that these factors, and other factors affecting the amount of water stored in reservoirs and underground, will cause sea level to rise by about 9 to 88 cm (about 4 to 35 inches) by 2100, with a central range estimate of 20-70 cm (8-28 inches) that I believe more likely encompasses what will occur. To determine the projected sea level rise at a particular location, the local rate of subsidence or uplift must also be accounted for.

24. ***More frequent and intense extreme weather events:*** The additional energy available from increased average temperature will drive an increase in evaporation, ensuring that more moisture will precipitate out as rain and snow. The increased rate of condensation releases additional energy to the atmosphere and intensifies convective (e.g., thunder-storm-like) motions in the atmosphere. Observations from many countries,

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[19] As an example, results from the New York Climate and Health project indicate that warmer temperatures significantly increase the likelihood of ozone exceedances in that region. National Assessment Synthesis Team, U.S. Global Change Research Program, *Climate Change Impacts on the United States, Overview* (Cambridge Univ. Press 2000), page 104.

including the U.S., indicate that such changes are already evident as a result of the warming during the 20th century, and these observed trends are very likely to continue, contributing to more frequent flooding and inundation in vulnerable regions. Of particular concern is the potential for an increase in the wind speed and peak rate of precipitation of major tropical cyclones (i.e., hurricanes and typhoons).

25. ***An increase in local flooding and coastal inundation:*** The increase in the frequency and intensity of intense convective rainfall events is likely to increase incidents of localized flooding. The increased wind speed and peak rate of precipitation from hurricanes, along with higher storm surges due to the increase in sea level and in hurricane winds, are likely to cause greater damage and put those in the paths of hurricanes (or along streams and rivers whose levels are raised by hurricanes) at greater risk of physical injury, property damage, and subsequent anguish. Soil compaction, sea level rise and recurrent severe storms are destroying approximately 20-30 square miles of Louisiana wetlands each year. These wetlands serve as the "shock absorber" for storm surges that could inundate New Orleans, significantly enhancing the risk to a major urban population. More frequent flooding and inundation have the potential for developing in other low-lying regions around the country, including along low-lying coastal areas on the Gulf of Maine, Cape Cod, Long Island and the New York metropolitan area and New Jersey, and further south along the Eastern Seaboard. The increased occurrence of very dry conditions not only increases the risk of forest fires that can wipe out homes and communities, but also sets the stage for the subsequent compounding effects of mudslides.

26. ***Climate change will impact water resources:*** More precipitation falling in more intense weather events will increase both flood- and drought-related damage. As soils

become saturated, more excess rain will run off into streams and rivers rather than be retained as soil moisture. At the same time, the increased temperatures will cause more rapid evaporation of what moisture does exist in the soil, leading to more rapid drying. In vulnerable regions, this drying will cause more dust to be lofted. In mountainous areas of the western U.S. where winter snowpack is an important source of springtime runoff into rivers and reservoirs, the warming projected in the climate scenarios used in the National Assessment will lead to sharp reductions in springtime snowpack and very significant shifts in the timing of snowmelt and reductions in warm season water resources.

27. ***Water quality is likely to be adversely affected:*** A wide range of potential influences are likely to affect water quality and increase the risk of disease from aquatic organisms harvested from rivers, estuaries, and coastal environments.[20] Increasing air temperatures and a longer warm season, for example, will increase stream and estuarine temperatures, allowing more rapid development of various microbial vectors. Additionally, changes in flow conditions are likely to allow increased salinity in estuarine areas in some regions. Pulses of higher precipitation, runoff, and flooding are also likely to augment the transport of non-point pollution and soil into rivers and estuaries. Moreover, higher storm surges[21] are very likely to increase destruction of coastal development, carrying polluting materials into freshwater and marine systems. Higher temperatures tend to enhance the rate of spread of invasive

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[20] National Assessment Synthesis Team, U.S. Global Change Research Program, *Climate Change Impacts on the United States, Overview* (Cambridge Univ. Press 2000), page 108.

[21] Because of wind creates waves in shallow water, the increase in storm surge height is estimated to be 50% greater than the increase in the depth (i.e., the rise in sea level).

species into water environments, and high precipitation conditions can exceed the capacity of combined sewage-storm water systems, necessitating release of untreated sewage to waterways.

28. ***Conditions are likely to be more conducive to the spread and persistence of various disease vectors:*** At present, many insect, tick, and rodent borne disease vectors in the U.S. are controlled by development practices, building and community design standards and the seasonal cycle of temperatures (for instance, persistent temperatures below freezing) that tends to limit reproduction or even kill off existing vectors. Warmer conditions and alteration of traditional precipitation amounts are likely to improve conditions for both existing and new vectors, both by expanding ranges in the U.S. for endemic vectors and by making it easier for pests carried in by travelers, ships, or freight to become established. Limiting diseases outbreaks will require enhanced and more expensive public health programs, greater use of pesticides, upgraded building and community design standards, and increased education and awareness by the public, all of which will necessitate increased resources.

Reducing U.S. Greenhouse Gas Emissions Will Lessen the Impacts of Global Warming

29. Very substantial cutbacks in CO_2 emissions must begin during the next few decades to significantly limit the warming projected for later in this century. The earlier the cutbacks begin, the more gradual and economical they may be phased-in.

30. The *U.S. Climate Action Report 2002* provides a breakdown of the U.S. emissions by end use sector.[22] U.S. emissions increased by almost 13 percent during the l990s. For 1999, the carbon emissions are given as:

End-Use Sector	1999 Emissions (Tg CO_2 equiv)	1999 Emissions (billion metric tons of carbon)	Percent of U.S. emissions
Industrial	1784	0.49	33%
Transportation	**1716**	**0.47**	**32%**
Residential	1036	0.28	19%
Commercial	864	0.24	16%
U.S. Territories	53	0.01	<1%
Total	5453	1.49	100%

31. Based on average emissions over the 1990s, the U.S. was responsible for emitting roughly 22% of the world's fossil fuel emissions during that decade and the U.S. transportation sector (mainly automobiles) was responsible for about 7% of global fossil fuel emissions. Within the U.S., the transportation sector is responsible for approximately 32% of national carbon emissions. The U.S. transportation sector is becoming an increasing share of U.S. emissions due to two trends: overall energy efficiency is improving in the industrial sector while the number of vehicles is growing, and the average emission of CO_2 per vehicle is increasing.[23]

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[22] U.S. Dept. of State, *U.S. Climate Action Report 2002*, page 41 (U.S. Government Printing Office 2002).

[23] Chapter 3 (Greenhouse Gas Inventory) in *U.S. Climate Action Report—2002*, pages 26 to 49, Government Printing Office, 2002. Table 3-4 on page 36 summarizes the trends in CO_2 emissions by year and vehicle type; total vehicle emissions increased by 16% from 1990 to 1999. Footnote (continued...)

32. Given the large emissions of CO_2 and other greenhouse gases from motor vehicles in the United States and the lead time needed to economically introduce changes into the motor vehicle fleet, emission reductions must be initiated in the near future in order to significantly reduce and delay the impacts of global warming. If the U.S. takes steps to reduce motor vehicle emissions, other countries are very likely to take similar actions regarding their own motor vehicles using technology developed in response to the U.S. program, thereby multiplying the total emission reduction benefit of the U.S. action. This would discernibly and significantly reduce and delay projected adverse consequences of global warming, and greatly improve the likelihood that there would be time for additional development and use of even better technologies. With such efforts, accompanied by progress in limiting other emissions, it would be much more likely that the extent of climate change could ultimately be limited to levels that would avoid the most serious impacts of global warming.

I declare under the penalty of perjury that the foregoing is true and correct.

Executed on June 18, 2004 in Washington, D.C.

/s/

Michael C. MacCracken

[23] (...continued)
14 on page 35 admits that the average miles per gallon achieved by the U.S. highway vehicle fleet decreased in 1998 and 1999 (the latest years for which information is available).

IN THE UNITED STATES COURT OF APPEALS
FOR THE DISTRICT OF COLUMBIA CIRCUIT

Commonwealth of Massachusetts, et al., Petitioners	)	Docket No. 03-1361 and consolidated cases (03-1362, 03-1363, 03-1364)
v.	)	
Environmental Protection Agency, Respondent	)	

DECLARATION OF MICHAEL P. WALSH

I, MICHAEL P. WALSH, declare as follows:

1. I am a mechanical engineer. I obtained a Bachelor of Sciences in Mechanical Engineering from Manhattan College, June 1966, and have spent my entire career, approximately 35 years, working on motor vehicle pollution control and energy issues. The first part of my career was spent in government service, initially with the City of New York (from 1970 to 1974) and then with the U.S. Environmental Protection Agency ("EPA") (from 1974 to 1981). With each agency, I served in various capacities and eventually as Director of its motor vehicle pollution control efforts. During my tenure, EPA issued many regulations to reduce motor vehicle emissions. For example, EPA promulgated the first diesel particulate standard in the world for light duty vehicles.

2. Since 1981 I have been an independent consultant advising governments and industries around the world on motor vehcle polluton technology, fuel reformulation, and other pollution reduction regulatory strategies. For example, for

several years I served as the Chairman of the World Bank Advisory Panel to the Mexico City Transport/Air Quality Management Program. Subsequently, I served in a similar capacity with the Chinese National Environmental Protection Agency. During the 1980s, I was an advisor to the U.S. Senate Environment and Public Works Committee during development of the 1990 Clean Air Act Amendments. I currently co-chair the Mobile Source Subcommittee of the U.S. EPA's Clean Air Act Advisory Committee, and am actively involved in projects in Brazil, Hong Kong, Mexico City, Vietnam, and China. I recently served as a member of the National Research Council "Committee on the Future of Personal Transport Vehicles in China." I have also been serving as the principal technical consultant to the Asian Development Bank regarding a regional technical assistance project, "Reducing Motor Vehicle Emissions in Asia" and served as a peer review expert to the European Commission during its recent deliberations regarding near zero sulfur fuels.

3. I have carried out projects for government bodies in the European Union, Japan, South Korea, Taiwan, China, Hong Kong, Philippines, Thailand, Indonesia (for U.S. AID), Vietnam, Malaysia, Singapore, Sri Lanka, India, Kuwait, Iran, Romania, Russia, Hungary, Poland, Mexico, Brazil, Canada and Chile. My consulting has included projects for numerous internatonal organizations such as the United Nations Environment Program, the World Bank, the Asian Development Bank, the World Health Organization and the Organization for Economic Cooperation and Development. My complete curriculum vitae is attached.

4. The following findings and conclusions are offered as my expert opinion, based on my education, qualifications, and experience, and based on my detailed knowledge of the history of the development and adoption of motor vehicle emission

controls in the United States and around the world over the past four decades.

5. First, the adoption of emission standards in the United States for a wide variety of motor vehicle emissions from 1968 to the present resulted in substantial investment by the automobile industry and its suppliers in technical solutions to reducing harmful emissions from motor vehicles. As a result of this investment, both vehicle manufacturers and their suppliers developed a variety of pollution control technologies. These technologies, in turn, have resulted in dramatic reductions in emissions of pollutants including hydrocarbons, carbon monoxide, oxides of nitrogen, particulate matter, and lead from vehicles produced and sold in the U.S.

6. Some of these technologies involved improvements and refinements to existing combustion engines, while others were add-on, post-combustion technologies. In some cases, fundamentally new technologies were developed and commercialized. One example is the development of electronic controls that optimize air/fuel and spark management systems; these innovations improved combustion and increased power and range while at the same time cutting conventional emissions, reducing fuel consumption, and reducing carbon dioxide emissions. Another example is the introduction of catalytic converters on most new cars starting with the 1975 model year, which not only reduced emissions dramatically but also allowed engines to be re-optimized for performance and fuel economy.

7. Second, once developed and demonstrated in the U.S., these technologies have subsequently spread around the world. To cite but one example, catalytic converter technology was developed during the 1970's to comply with U.S. vehicle emissions standards. Other countries subsequently adopted similar standards based on the U.S. experience, and similar

technology is now used on all new cars produced and sold in Japan, the European Union, South Korea, China, Taiwan, Thailand, India, Australia, Brazil and Mexico. In fact, approximately 90 percent of all new gasoline fueled vehicles sold in the world today are equipped with catalyst technology and emit approximately an order of magnitude lower emissions per mile driven than vehicles emitted before this technology was developed for the U.S. market. In the same way, electronic controls are now the norm in these countries as well.

8. Similar patterns are starting to emerge with regard to heavy-duty vehicles. The U.S. recently tightened heavy-duty engine emissions standards to force the development of new low emissions technologies. In response, engine manufacturers and suppliers are currently investing substantial resources to develop advanced technologies, which are expected to be commercialized later this decade. Some vehicles equipped with these advanced technologies have already been introduced into the market. Both the European Union and Japan have also indicated that they will further tighten their heavy-duty standards to take advantage of these emerging technologies developed in response to U.S. regulatory strategies, as well as to force the introduction of additional low emissions technologies.

9. Motor vehicles are substantial sources of greenhouse gas emissions that contribute to global warming, including carbon dioxide, methane, nitrous oxide, and hydrofluoro-carbons. For example, in the U.S., emissions from on-road transportation (i.e., passenger cars, light duty and other trucks, and buses) were responsible for 24% of U.S. annual CO_2

emissions in 2001.[1]

10. On the basis of my experience with the control of other pollutants summarized above, I have no doubt that establishing emissions standards for pollutants that contribute to global warming would lead to investment in developing improved technologies to reduce those emissions from motor vehicles, and that successful technologies would gradually be mandated by other countries around the world.

11. This is, in fact, already occurring with regard to reducing motor vehicle emissions of hydrofluorocarbons (HFCs) from vehicle air conditioning systems. The EPA, the California Air Resources Board, and the European Union have been successfully collaborating for several years to develop vehicle air conditioning systems that have lower HFC leak rates, that use alternative HFCs with lower global warming potency, or that use other refrigerants altogether. Because many of these systems are more efficient than current equipment, they also indirectly reduce vehicle tailpipe emissions of CO_2. Both California and the European Union intend to require these improved systems by regulation. I note that the Society of Automotive Engineers recently announced a partnership by regulatory authorities, automobile and component makers, and others to dramatically reduce motor vehicle HFC emissions in the U.S. and other countries.[2]

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[1] U.S. Environmental Protection Agency, *Emissions Inventory 2003: Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2001*, Tables ES-1, 2-7 (April 2003) (avail. at http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html).

[2] SAE Internatonal, "*Ambitious Mobile Air Conditioning Climate Protection Goal Announced*" (Apr. 22, 2004), available at http://www.sae.org/news/ (continued...)

12. In conclusion, based on my education, experience, and expertise, it is my strong opinion that U.S. regulatory requirements to reduce greenhouse gas emissions from motor vehicles would lead to investment and successful action to reduce those emissions by vehicle manufacturers that serve the U.S. market. In turn, efforts to reduce emissions from U.S. motor vehicles would proliferate around the world as other countries again adopted similar regulatory requirements. Successfully reducing greenhouse gas emissions from vehicles in the U.S. and other countries would substantially and measurably slow and reduce the build-up of these pollutants in the atmosphere and would substantially and measurably mitigate the impacts of global warming.

I declare under the penalty of perjury that the foregoing is true and correct.

Executed on 10 June 2004, in Arlington, VA.

/s/

Michael P. Walsh

[2] (...continued)
releases/mobileac.htm.

MICHAEL P. WALSH

3105 North Dinwiddie Street, Arlington, VA 22207 USA • 703 241 1297, mpwalsh@igc.org, http://Walshcarlines.com

OBJECTIVE

To assist governments in designing or implementing programs to address motor vehicle related pollution or energy problems.

SKILLS

Demonstrated proficiency in designing and managing motor vehicle pollution control and energy programs.

Extensive background in all technical phases of motor vehicle pollution and energy problems at the local, national and International level.

Unique policy overview regarding global motor vehicle air pollution and energy issues.

Expertise in working with many countries around the world in designing and implementing optimal motor vehicle air pollution control programs.

EDUCATION

Bachelor of Science (Mechanical Engineering), Manhattan College, New York, 1966

Misc. graduate combustion courses, Princeton University, New Jersey, 1969-70.

EXPERIENCE

1981 to Present: Technical Consultant

Clients have included American Lung Association, Asian Development Bank, Congressional Office of Technology Assessment, Conservation Foundation, Corning International,

Envirotest, League of Women Voters, Manufacturers of Emission Controls Association, NESCAUM, Organization For Economic Cooperation and Development (OECD), Systems Control, United Nations Environment Program, United States Senate Committee on Environment and Public Works, the World Resources Institute, the Environmental Protection Agencies of Brazil, Hong Kong, Mexico, Norway, Sweden, Switzerland, Thailand, Taiwan among others with efforts directed at evaluations of costs and benefits of motor vehicle emission standards, design of emission control programs in developing countries, alternative compliance approaches, analysis of Inspection and Maintenance programs to improve in-use vehicle emissions performance, alternative fuels and the need for control of diesel particulate. Recent efforts have focused on Southeast Asia for the World Bank, UNIDO and the Asian Development Bank.

1978 to 1981: Deputy Assistant Administrator, Mobile Source Air Pollution Control, U.S. Environmental Protection Agency

Directed U.S. program of standard setting, technology assessment, test procedure development, Certification, fuel economy measurement, and technical assistance to States in implementing motor vehicle Inspection and Maintenance programs. Responsible for developing the first diesel particulate standard in the world. Major EPA I/M effort initiated.

1977 to 1978: Special Assistant to Assistant Administrator for Air, Noise and Radiation, U.S. Environmental Protection Agency

Principal advisor to Assistant Administrator on technical and policy issues related to State Plans for achieving health based

air quality standards. Involved in air quality standard setting, air quality monitoring, reasonable controls on sources of polluton, etc.

1974 to 1977: Chief, Technical Support Branch, Office of Enforcement, U.S. Environmental Protection Agency

Lead the technical effort in mobile source enforcement related to testing and data handling in support of Recall and Assembly Line test programs as well as Inspection and Maintenance. Conducted comprehensive review of motor vehicle control program as part of strategy development.

1970 to 1974: Director, Bureau of Motor Vehicle Pollution Control, City of New York, Department of Air Resources Department

Responsible for New York City's motor vehicle pollution control effort with particular focus on the taxicab and truck problems.

AWARDS

Selected for Meritorious Rank in the U.S. Senior Executive Service, 1980.

Lloyd L. Withrow Distinguished Speaker Award from the Society of Automotive Engineers, 1999.

First recipient of the U.S. Environmental Protection Agency Thomas W. Zosel Outstanding Individual Achievement Award for outstanding achievement, demonstrated leadership, and a lastng commitment to promoting clean air, 2000.

California Air Resources Board's "Haagen Smit" award for his "global efforts towards mobile source emissions reduction, 2003.

MEMBERSHIPS

Society of Automotive Engineers

Air and Waste Management Assocation

American Association for the Advancement of Science

ADVISORY GROUPS

American Lung Association, National Action Panel on the Environment

Past Chairman, World Bank External Advisory Panel on Mexico City Transport/Air Quality Management Program

South Coast Air Quality Management District, Technology Advancement Office, Clean Fuels Advisory Committee

Past Chairman, Inspection and Maintenance Peer Review Panel, California Air Resources Board & California Senate (1994)

Past Member, National Research Council, Transportation Research Board, Committee for the Study of Public Policy for Surface Freight Transportation

Past Member, Expert Advisory Panel, Tehran Transport Global Environment Facility Project

Co Chair, US Environmental Protection Agency Sub Committee on Mobile Source Air Pollution Control

Past Chairman, Internatonal Expert Advisory Panel, China National Environmental Protection Agency

Past Member, National Research Council, Transportation Research Board, Committee for the Study of Transportation Options for Megacities in Developing Nations, Panel on Transportation Options

Member, International Advisory Board, Wuppertal Institute for Climate, Environment & Energy

Past Member, Transportation Working Group, China Council for International Cooperation and Environmental Development(CCICED)

Member, National Academy of Engineering, Panel on the Future of the Automobile in China

Past Member Independent Review Panel for US 2007 Heavy Duty Standards & Low Sulfur Fuels

OTHER

Editor of Car Lines, an International Newsletter Dealing With Motor Vehicle Pollution Control and Energy Issues

Invited Lecturer at several universities including Yale, Harvard, Johns Hopkins University.

Married
3 Children
Date of Birth - 8/17/43
US Citizen