FOIA Number: 2017-1095-F

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

Collection/Record Group: Clinton Presidential Records

Subgroup/Office of Origin: Council of Economic Advisers

Series/Staff Member: Jeffrey Frankel

Subseries:

OA/ID Number: 13723

FolderID:

Folder Title:
Global Warming State Department Vol 1 [1]

Stack:	Row:	Section:	Shelf:	Position:
S	20	4	11	1

United States Department of State

Assistant Secretary of State for Oceans and International Environmental and Scientific Affairs

Washington, D.C. 20520

July 3, 1997

TO: Distribution

FROM: OES - Rafe Pomerance, Acting

SUBJECT: Assistant Secretaries Group review of the U.S. National Communication

The revised draft version of the U.S. National Communication will be available on Monday, July 7, 1997. Please contact the Office of Global Change, at (202) 647-4069, on Monday to arrange to have someone from your agency pick up a copy of the document. Dr. Jonathan Pershing of that office may be reached with any specific questions regarding the text.

We remain on a very tight publishing timeline, and will need your comments by COB, Wednesday, July 9. If we do not hear from you, we will assume clearance. Please remember that your clearance represents your agency sign off on the document. The document has undergone several rounds of review at the staff level; the only changes that should be made at this juncture are those which must be made to address significant outstanding policy problems.

I would like to take this opportunity to extend my appreciation through you to those on your staffs who have made it possible to prepare this report.

cc: IWG/GEA - Climate Subgroup

Total number of pages in this transmission: 2

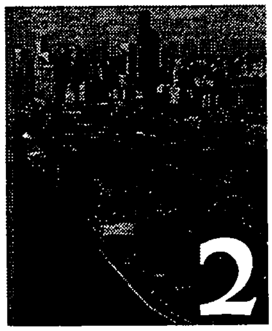
DISTRIBUTION:

Organization	Name	Fax	Phone
State	Eileen Claussen	647-0217	647-1554
	Rafe Pomerance		647-2232
Commerce	Jeffrey Hunker	482-4636	482-6055
OSTP	Rosina Bierbaum	456-6025	456-6077
CEA	Alicia Munnell	395-6958	395-5036
NEC	Jeff Frankol	395-6947	395-5046
Treasury	Jon Gruber	622-2633	622-2200
Justice	Lois Schiffer	514-0557	514-2701
	Jim Simon		
Interior	Brooks Yeager	208-4561	208-6182
NOAA	Terry Garcia	482-6318	482-3567
OMB	T.J. Glauthier	395-4639	395-4561
	Josh Gottbaum	395-1005	395-3060
USTR	Jennifer Haverkamp	395-4579	395-7320
USDA	Charlie Rawls	720-5437	720-6158
DOE	Mark Chupka	586-0861	586-5523
	Joe Romm	586-9260	586-9220
EPA	Mary Nichols	260-5155	260-7400
	David Doniger		
	David Gardiner	260-0275	260-4332
DOT	Frank Kruesi	366-7127	366-4544
OVP	Pete Jordan	456-9500	456-9513
PCSD	Marty Spitzer	408-6839	408-5296
	Christine Ervin	408-5296	408-6839
CCTF	Dirk Forrister	343-1162	343-1060
	Steve Seidel		
USAID	David Hales	703-875-4639	703-875-4205
DOL	Ed Montogmery	219-4902	219-5108
DOD	Sherri Goodman	703-693-7011	703-695-6639

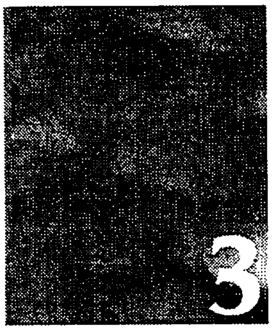
Mc
AM
MM
JS

1997 Submission of the United States of America
Under the United Nations Framework
Convention on Climate Change

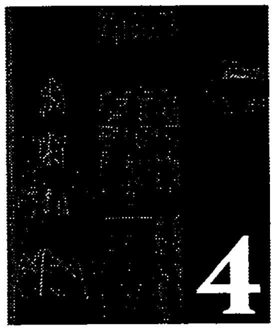
1 Introduction



2 National Circumstances



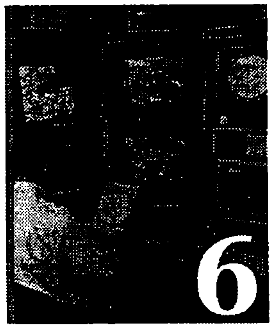
3 Greenhouse Gas Inventory



4 Mitigating Climate Change

contents

5 Vulnerability and Adaptation



6 Research and Systematic Observation

7 Education, Training, and Outreach

8 International Activities

1

introduction

Since the historic gathering of representatives from 172 countries at the Earth Summit in Rio de Janeiro in June 1992, issues of environmental protection have remained high on national and international priorities. Climate change is one of the most visible of these issues—and one in which some of the most significant progress has been made since the 1992 session. Perhaps the crowning achievement in Rio was the adoption of the United Nations Framework Convention on Climate Change (FCCC). This Convention represented a shared commitment by nations around the world to reduce the potential risks of a major global environmental problem. Its ultimate objective is to:

> [A]chieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic [human] interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner.

However, since the 1992 Earth Summit, the global community has found that actions to mitigate climate change will need to be more aggressive than anticipated. At the same time, the rationale for action has proven more compelling. Few "Annex I" countries (the Climate Convention's term for developed

countries, including Organization for Economic Cooperation and Development (OECD) member countries and countries with economies in transition to market economies) have demonstrated an ability to meet the laudable, albeit nonbinding, goal of the Convention—"to return emissions of greenhouse gases to their 1990 levels by the end of the decade." While voluntary programs have demonstrated that substantial reductions are achievable at economic savings or low costs, the success of these programs has been overshadowed by lower-than-expected energy prices as well as higher-than-expected economic growth and electricity demand, among other factors.

Recognizing that even the most draconian measures would likely be insufficient to reverse the growth in greenhouse gases and return U.S. emissions to their 1990 levels by the year 2000, new U.S. efforts are focusing most intensively on the post-2000 period. Thus, while some new voluntary actions have been proposed (and are included in this report) that will have effects prior to the year 2000, an effort to develop a comprehensive program to address rising U.S. greenhouse gas emissions is being developed and will be reported in the next U.S. communication.

In spite of difficulties in meeting a domestic goal to return emissions to their 1990 levels, the U.S. commitment to addressing the climate change problem remains a high priority. President Clinton, in remarks made in November 1996, both underlined U.S. concerns and exhorted the nations of the world to act:

> We must work to reduce harmful greenhouse gas emissions. These gases released by cars and power plants and burning forests affect our health and our climate. They are literally warming our planet. If they continue unabated, the consequences will be nothing short of devastating .... We must stand together against the threat of global warming. A greenhouse may be a good place to raise plants; it is no place to nurture our children. And we can avoid dangerous global warming if we begin today and if we begin together.

Difficulties in meeting the "aim" of the Climate Convention prompted the international community, gathered at the first meeting of the Conference of the Parties to the FCCC (held in Berlin, Germany, in March 1995), to agree on a new approach to addressing the climate change problem. At their first session, the Parties decided to negotiate a new legal instrument containing appropriate next steps under the Convention. At the Second Conference of the Parties (COP-2), the United States expressed its view that the new agreement should include three main elements:

- a realistic and achievable binding target (instead of the hortatory goals and nonbinding aims of the existing Convention),
- flexibility in implementation, and
- the participation of developing countries.

Each of these elements was included in a Ministerial Declaration agreed to at COP-2, and the United States expects that a legal instrument containing these elements will be one of the outcomes from the Third Conference of the Parties, to be held in Kyoto, Japan, in December 1997.

As international negotiations continue on a new legal commitment, the United States is assessing options for a domestic program. The results of this analytical effort are

being used to inform the U.S. negotiating positions, and will subsequently be used to develop compliance strategies to meet any commitments established under the new regime.

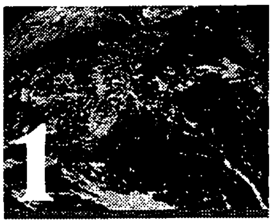
While the Parties involved in the negotiations are determining next steps for collective action, all countries are still actively pursuing the programs adopted earlier in the decade to control emissions. This document describes the current U.S. program. It represents the second formal U.S. communication under the FCCC, as required under Articles 4.2 and 12. As with the *Climate Action Report* published by the United States in 1994, it is a "freeze frame"—a look at the current moment in time in the U.S. program. This report does not predict additional future activities. Nor is it intended to be a substitute for existing or future decision-making processes—whether administrative or legislative—or for additional measures developed by or with the private sector.

This document has been developed using the methodologies and format agreed to at the first meeting of the Conference of the Parties to the FCCC, and modified by the second meeting of the Conference of the Parties and by sessions of the Convention's Subsidiary Body on Scientific and Technological Advice and the Subsidiary Body on Implementation. The United States assumes that this communication, like those of other countries—and like the preceding U.S. communication—will be subject to a thorough review, and discussed in the evaluation process for the Parties of the Convention. Even though the measures listed in this report are not expected to reduce U.S. emissions below 1990 levels by the year 2000, the United States believes that many of the climate change actions being implemented have been successful at reducing emissions, send valuable signals to the private sector, and may be appropriate models for other countries. The U.S. experience should also ensure that future efforts are more effective in reversing the rising trend of emissions and returning U.S. emissions to more environmentally sustainable levels.

The Science

The 1992 Convention effort was largely predicated on the scientific and technical information produced by the Intergovernmental Panel on Climate Change (IPCC) in its 1990 report. The IPCC consists of more than two thousand of the world's best scientists with expertise in the physical, social, and economic sciences relevant to the climate issue. The United States stands firmly behind the IPCC's conclusions. As the actions being taken by the United States ultimately depend on the nation's understanding of the science, it is important to at least briefly review this information here.

The Earth absorbs energy from the sun in the form of solar radiation. About one-third is reflected, and the rest is absorbed by different components of the climate system, including the atmosphere, the oceans, the land surface, and the biota. The incoming energy is balanced over the long term by outgoing radiation from the Earth–atmosphere system, with outgoing radiation taking the form of long-wave, invisible infrared energy. The magnitude of this outgoing radiation is affected in part by the temperature of the Earth–atmosphere system.



Several human and natural activities can change the balance between the energy absorbed by the Earth and that emitted in the form of long-wave infrared radiation. On the natural side, these include changes in solar radiation (the sun's energy varies by small amounts—approximately 0.1 percent over an eleven-year cycle—and variations over longer periods also occur). They also include volcanic eruptions, injecting huge clouds of sulfur-containing gases, which tend to cool the Earth's surface and atmosphere over a few years. On the human-induced side, the balance can be changed by emissions from land-use changes and industrial practices that add or remove "heat-trapping" or "greenhouse" gases, thus changing atmospheric absorption of radiation.

Greenhouse gases of policy significance include carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); the chlorofluorocarbons (CFCs) and their substitutes, including hydrofluorocarbons (HFCs); the long-lived fully fluorinated hydrocarbons, such as perfluorocarbons (PFCs); and ozone (O_3). Although most of these gases occur naturally (the exceptions are the CFCs, their substitutes, and the long-lived PFCs), the concentrations of all of these gases are changing as a result of human activities.

For example, the atmospheric concentration of carbon dioxide has risen about 30 percent since the 1700s—an increase responsible for more than half of the enhancement of the trapping of the infrared radiation due to human activities. In addition to their steady rise, many of these greenhouse gases have long atmospheric residence times (several decades to centuries), which means that atmospheric levels of these gases will return to preindustrial levels only if emissions are sharply reduced, and even then only after a long time. Internationally accepted science indicates that increasing concentrations of greenhouse gases will raise atmospheric and oceanic temperatures and could alter associated weather and circulation patterns.

In a report synthesizing its second assessment and focusing on the relevance of its scientific analyses to the ultimate objective of the Convention, the IPCC concluded:

- Human activities—including the burning of fossil fuels, land use, and agriculture—are changing the atmospheric composition. Taken together, they are projected to lead to changes in global and regional climate and climate-related parameters, such as temperature, precipitation, and soil moisture.
- Some human communities—particularly those with limited access to mitigating technologies—are becoming more vulnerable to natural hazards and can be expected to suffer significantly from the impacts of climate-related changes, such as high-temperature events, floods, and droughts, potentially resulting in fires, pest outbreaks, ecosystem loss, and an overall reduction in the level of primary productivity.

The IPCC also concluded that, given the current trends in emissions, global concentrations of greenhouse gases are likely to grow significantly through the next century and beyond, and the adverse impacts from these changes will become greater. The remainder of this report seeks to elucidate the programs, policies, and measures being taken in the

Principal Conclusions of the IPCC's Second Assessment Report

While the basic facts about the science of climate have been understood and broadly accepted for years, new information is steadily emerging—and influencing the policy process. In 1995, the IPCC released its *Second Assessment Report*, which not only validated most of the IPCC's earlier findings, but because of the considerable new work that had been undertaken during the five years since its previous full-scale assessment, broke new ground. The report is divided into three sections: physical sciences related to climate impacts; adaptation and mitigation responses; and cross-cutting issues, including economics and social sciences.

The Climate Science

- Human activities are changing the atmospheric concentrations and distributions of greenhouse gases and aerosols.
- Global average temperatures have increased about 0.3–0.6°C (about 0.5–1.0°F) over the last century.
- The ability of climate models to simulate observed trends has improved—although there is still considerable regional uncertainty with regard to changes.
- The balance of evidence suggests there is a discernible human influence on global climate.
- Aerosol sulfates (a component of acid rain) offset some of the warming by greenhouse gases.
- The IPCC mid-range scenario projects an increase of 2.0°C (3.7°F) by 2100 (with a range of 1.0–3.5°C (about 1.8–6.5°F).
- The average warming projected in the IPCC mid-range scenario is greater than any seen in the last ten thousand years.
- Sea level is projected to rise (due to thermal expansion of the oceans, and melting of glaciers and ice sheets) by about 50 centimeters (20 inches) by 2100 (with a range of 15–95 centimeters (about 6–38 inches).
- Even after a stabilization of greenhouse gas concentrations, temperatures would continue to increase for several decades, and sea level would continue to rise for centuries.

Vulnerability, Likely Impacts, and Possible Responses

- Climate change is likely to have wide-ranging and mostly adverse effects on human health. Direct and indirect effects can be expected to lead to increased mortality.
- Coastal infrastructure is likely to be extremely vulnerable. A 50-centimeter (20-inch) rise in sea level would place approximately 120 million people at risk.
- Natural and managed ecosystems are also at risk: forests, agricultural areas, and aquatic and marine life are all susceptible.
- However, adaptation and mitigation options are numerous. Significant reductions in net greenhouse gas emissions are technically possible and can be economically feasible, using an extensive array of technologies and policy measures that accelerate technology development, diffusion, and transfer.

Socioeconomic Issues

- Early mitigation may increase flexibility in moving toward a stabilization of atmospheric concentrations of greenhouse gases. Economic risks of rapid abatement must be balanced against risks of delay.
- Significant "no regrets" opportunities are available in most countries. Next steps must recognize equity considerations.
- Costs of stabilization of emissions at 1990 levels in OECD countries could range considerably (from a gain of $60 billion to a loss of about $240 billion) over the next several decades.

United States to begin moving away from this trend of increasing emissions, and to help move the world away from the trend of globally increasing concentrations of greenhouse gases.

National Circumstances

In responding to the threat of global climate change, U.S. policymakers must consider the special circumstances created by a unique blend of challenges and opportunities. The National Circumstances chapter of this report attempts to explain the particular situation in the United States—including its climate, natural resources, population trends, economy, energy mix, and political system—as a backdrop for understanding the U.S. perspective on global climate change.

The United States is unusual in that it encompasses a wide variety of climate conditions within its borders, from subtropical to tundra. This diversity complicates the discussion of impacts of global climate change within the United States because those impacts would vary widely. This diversity also adds to U.S. emission levels, as heating and cooling demands drive up emissions. Recent record levels of precipitation—both in snowfall and rain—consistent with what could be expected under a changed climate, have raised the awareness of climate impacts at the local and regional levels, and may make it somewhat easier to predict the effects of increased precipitation.

The United States also is uncommonly rich in land resources, both in extent and diversity. U.S. land area totals about 931 million hectares (2.3 billion acres), including grassland pasture and range, forest, and cropland. Forested land has been increasing, while grasslands and croplands are slowly declining and being converted to other uses. The decline in wetlands has slowed significantly as a result of the "no net loss" policy being implemented.

With just over 265 million people, the United States is the third most populous country in the world, although population density varies widely throughout the country, and is generally very low. Although population increase is moderate from a global perspective, it is high relative to the average for all industrialized countries. Moreover, the number of households is growing rapidly. These and other factors drive U.S. emissions to higher per capita rates than those in most other countries with higher population densities, smaller land areas, or more concentrated distribution of resources to population centers.

The U.S. market economy is based on property rights and a reliance on the efficiency of the market as a means of allocating resources. The government plays a key role in addressing market failures and promoting social welfare, including through the imposition of regulations on pollutants and the protection of property rights, but is cautious in its interventions. Thus, the infrastructure exists to limit emissions of greenhouse gases—although the strong political and economic preference is to undertake such controls through flexible and cost-effective programs, including voluntary programs and market instruments, where appropriate.

U.S. economic growth averaged 3 percent annually from 1960 to 1993, and employment nearly tripled as the overall labor force participation rate rose to 66 percent. The service sector—which includes communications, utilities, finance, insurance,

and real estate—has grown rapidly, and now accounts for more than 36 percent of the economy. Increasing U.S. dependence on trade heightens concerns about the competitiveness effects of climate policies.

During the 1980s, the U.S. budget deficit grew rapidly, as did the ratio of debt to gross domestic product, and a political consensus emerged on the goal of a balanced budget. The result is a tighter federal budget with many competing priorities.

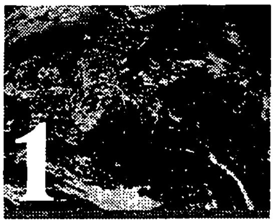
The United States is the world's largest energy producer and consumer. Abundant resources of all fossil fuels have contributed to low prices and specialization in relatively energy-intensive activities. Energy consumption has nearly doubled since 1960, and would have grown far more, because of growth in the economy, population, and transportation needs, had it not been for impressive reductions in U.S. energy intensity. Industrial energy intensity has declined most markedly, due to structural shifts and efficiency improvements. In the residential and commercial sectors, efficiency improvements largely offset the growth in the number and size of both residential and commercial buildings. Likewise, in the transportation sector, efficiency moderated the rise in total fuel consumption from 1973 to 1995 to only 26 percent, despite dramatic increases in both the number of vehicles and the distances they are driven. Fossil fuel prices below levels assumed in the 1993 *Climate Change Action Plan*, however, have contributed to the unexpectedly large growth in U.S. emissions.

While unique national circumstances point to the reasons for the current levels (and increases) in U.S. emissions, they also suggest the potential for emission reductions. Successful government and private-sector programs are beginning to exploit some of the inefficiencies in the manufacturing sector. The development of new, climate-friendly technologies is a rapidly growing industry, with significant long-term potential for domestic and international emission reductions.

Greenhouse Gas Inventory

Inventorying the national emissions of greenhouse gases is a task shared by several departments within the executive branch of the federal government, including the Environmental Protection Agency, the Department of Energy and the Department of Agriculture. The Greenhouse Gas Inventory chapter summarizes the most current information on U.S. greenhouse gas emission trends—and represents the 1997 submission from the United States in fulfillment of its annual inventory reporting obligation. The estimates presented in this chapter were compiled using methods consistent with those recommended by the *IPCC Guidelines for National Greenhouse Gas Inventories*; therefore, the U.S. emissions inventory should be comparable to those submitted by others under the FCCC.

Table 1-1 summarizes the recent trends in U.S. greenhouse gas emissions from 1990 to 1995. The three most important anthropogenic greenhouse gases are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). Hydrofluorocarbons (HFCs) are also inventoried. Consistent with the requirements in the Climate Convention only to address emissions of gases not controlled by the *Montreal Protocol on Substances That Deplete the*



Ozone Layer, chlorofluorocarbon (CFC) emissions are not inventoried, nor are mitigation measures for these compounds described.

Overall, U.S. greenhouse gas emissions have increased annually by just over one percent. The trend of U.S. emissions—which decreased from 1990 to 1991, and then increased again in 1992—is a consequence of changes in total energy consumption resulting from the U.S. economic slowdown in the beginning of this decade and its subsequent recovery.

Carbon dioxide accounts for the largest share of U.S. greenhouse gases—approximately 85 percent—although the carbon sinks in forested lands offset CO_2 emissions by about 8 percent. During 1990–95, greenhouse gas emissions continued to rise in the United States, with CO_2 increasing approximately 6 percent, methane approximately 4 percent,

Table 1-1

Recent Trends in U.S. Greenhouse Gas Emissions: 1990–1995
(MMTs of Carbon Equivalent)

Gases and Sources	Emissions—Direct and Indirect Effects					
	1990	1991	1992	1993	1994	1995
Carbon Dioxide (CO_2)	**1,228**	**1,213**	**1,235**	**1,268**	**1,291**	**1,305**
Fossil Fuel Combustion	1,336	1,320	1,340	1,370	1,391	1,403
Industrial Processes and Other	17	16	17	18	19	19
Total	*1,353*	*1,336*	*1,357*	*1,388*	*1,410*	*1,422*
Forests (sink)*	(125)	(123)	(122)	(120)	(119)	(117)
Methane (CH_4)	**170**	**172**	**173**	**171**	**176**	**177**
Landfills	56	58	58	60	62	64
Agriculture	50	51	52	52	54	55
Coal Mining	24	23	22	20	21	20
Oil and Natural Gas Systems	33	33	34	33	33	33
Other	6	7	7	6	6	6
Nitrous Oxide (N_2O)	**36**	**37**	**37**	**38**	**39**	**40**
Agriculture	17	17	17	18	18	18
Fossil Fuel Consumption	11	11	12	12	12	12
Industrial Processes	8	8	8	8	9	9
HFCs	**12**	**12**	**13**	**14**	**17**	**21**
PFCs	**5**	**5**	**5**	**5**	**7**	**8**
SF_6	**7**	**7**	**8**	**8**	**8**	**8**
U.S. Emissions	**1,583**	**1,570**	**1,592**	**1,624**	**1,657**	**1,676**
Net U.S. Emissions	**1,458**	**1,447**	**1,470**	**1,504**	**1,538**	**1,559**

Note: The totals presented in the summary tables in this chapter may not equal the sum of the individual source categories due to rounding.

* *These estimates for the conterminous United States for 1990-91 and 1993-95 are interpolated from forest inventories in 1987 and 1992 and from projections through 2040. The calculation method reflects long-term averages, rather than specific events in any given year.*

N_2O nearly 10 percent, and HFCs approximately 7 percent. Fossil fuel combustion accounts for 99 percent of total U.S. CO_2 emissions. (Chapter 3 of this report explains the use of MMTCE in converting emissions of greenhouse gases to carbon equivalents.)

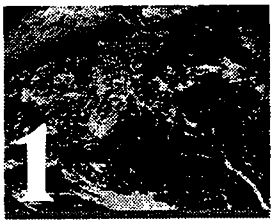
Although methane emissions are lower than CO_2 emissions, methane's footprint is large: in a 100-year time span it is considered to be twenty-one times more effective than CO_2 at trapping heat in the atmosphere and is responsible for about 10 percent of the warming caused by U.S. emissions. In addition, in the last two centuries alone, methane concentrations in the atmosphere have more than doubled. Emissions of methane are largely generated by landfills, agriculture, oil and natural gas systems, and coal mining, with landfills comprising the single largest source of the gas. In 1995, methane emissions from U.S. landfills were 63.5 MMTCE, equaling approximately 36 percent of total U.S. methane emissions. Agriculture supplied about 30 percent of U.S. methane emissions in that same year.

Nitrous oxide is also emitted in much smaller amounts than carbon dioxide in the United States and is responsible for approximately 2.4 percent of the U.S. share of the greenhouse effect. However, like methane, it is a more powerful heat trap—310 times more powerful than carbon dioxide at trapping heat in the atmosphere over a 100-year period. The main anthropogenic activities producing nitrous oxide are agriculture, fossil fuel combustion, and the production of adipic and nitric acids. Figures from 1995 show the agricultural sector emitting 46 percent of the total (18.4 MMTCE), with fossil fuel combustion generating 31 percent.

Hydrofluorocarbons (HFCs) are among the compounds introduced to replace ozone-depleting substances, which are being phased out as a result of the Vienna Convention and its *Montreal Protocol on Substances That Deplete the Ozone Layer*, and the Clean Air Act Amendments of 1990. Because HFCs and similar compounds are less harmful to the stratospheric ozone layer than CFCs, they are less stringently regulated under the *Montreal Protocol*. However, because they have significant potential to alter the Earth's radiative balance, they are included in this inventory. Many of the compounds of this nature are extremely stable and remain in the atmosphere for extended periods of time, which results in a significant atmospheric accumulation over time. U.S. emissions of these gases have risen nearly 60 percent as they are phased in as substitutes for gases that are no longer allowed under the *Montreal Protocol*—a rate of growth that is not anticipated to continue. Currently, HFCs account for less than 2 percent of U.S. radiative forcing.

Mitigating Climate Change

In October 1993, in response to the threat of global climate change, President Clinton and Vice President Gore announced the *Climate Change Action Plan* (CCAP). The Plan was designed to reduce U.S. emissions of greenhouse gases, while guiding the U.S. economy toward environmentally sound economic growth into the next century. This report updates the programs in the CCAP (including an appendix providing one-page descriptions of each program), describes several additional initiatives developed to further reduce emission growth rates, and



estimates future emissions based on the current set of practices and programs.

CCAP programs represent an effort to stimulate actions that are both profitable for individual private-sector participants as well as beneficial to the environment. Currently, more than forty programs are in effect, combining efforts of the government at the federal, state, and local levels with those of the private sector. The CCAP has five goals: preserving the environment, enhancing sustainable growth environmentally and economically, building partnerships, involving the public, and encouraging international emission reductions.

Carbon dioxide emissions constitute the bulk of U.S. greenhouse gas emissions. CCAP recognizes that investing in energy efficiency is the most cost-effective way to reduce these emissions. The largest proportion of CCAP programs contains measures that reduce carbon dioxide emissions while simultaneously enhancing domestic productivity and competitiveness. Other programs seek to reduce carbon dioxide emissions by investing in renewable-energy and other low-carbon, energy-supply technologies, which will also provide longer-term benefits, such as increased efficiency and related cost-savings and pollution prevention. A smaller number of programs are targeted at methane, nitrous oxide, and other greenhouse gases (Table 1–2).

A review and update of the CCAP was initiated in 1995, involving a federal government interagency review process and a public hearing and comment period. Revisions to the CCAP (and to the calculation of the effects of its measures) were initiated in light of comments received during this process and are reflected in this document. In addition, as called for under FCCC reporting guidelines, the projections of the effects of measures taken are extended to the year 2020, with the understanding that uncertainties become greater in more distant years.

One of the principal products of the review was an assessment of the effectiveness of the CCAP programs, which were rated to be successful at reducing emissions. Currently, more than 5,000 organizations are participating in programs around the United States. The pollution-prevention benefits of these innovative programs are beginning to multiply rapidly in response to the groundwork laid and the partnerships made. In all, the programs are expected to achieve a large portion of the reductions projected in the CCAP. In fact, it is estimated that these programs will result in energy cost savings of $10 billion annually in 2000.

However, the review has also made clear the significantly reduced impact to be expected from the programs as a result of the nearly 40 percent reduction of CCAP funding by Congress from the amount requested by the President, higher-than-expected electricity demand, and lower-than-expected energy prices. In addition, before the programs' implementation, CCAP program managers could not always anticipate the impacts of projected climate change emission reductions. Information available from the first tranche of activity was considered in developing the current projections.

A second product of the review was the identification of several measures that have since been added to the CCAP portfolio. The most significant of these is the Environmental Stewardship Initiative, which greatly

expands activities already included in the CCAP, and focuses on reducing the emissions of extremely potent greenhouse gases from three industrial applications—semiconductor production, electrical transmission and distribution systems, and magnesium casting. The expanded initiative is anticipated to reduce emissions by an additional 6.5 MMTCE by 2000, and 10.0 MMTCE by 2010. Other programs include improving energy efficiency in the construction of and supply of energy to commercial and industrial buildings, expanding residential markets for energy-efficient lighting products, and providing information on renewable energy to reduce barriers to the adoption of clean technologies.

The analysis of individual actions is integrated with revised forecasts of economic growth, energy prices, program funding, and regulatory developments to provide an updated comprehensive perspective on current and projected greenhouse gas emission levels. This analysis involved an updating of the baseline calculation in light of new economic assumptions regarding energy prices, economic growth, and technology improvements, among other factors. In 1993, the first U.S. submission projected year 2000 baseline emissions to be 106 MMTCE above their 1990 levels; with current program funding, emissions are now projected to exceed 1990 levels by 187 MMTCE. Two principal factors are responsible:

- The analysis used to develop CCAP significantly underestimated the reductions that would be needed by programs to return emissions to 1990 levels by the year 2000. This was due to several factors, including lower-than-expected fuel prices, strong economic growth, regulatory limitations within and outside of CCAP, and improved information on emissions of some potent greenhouse gases).
- In addition, diminished levels of funding by Congress have affected both CCAP programs and other federal programs that reduce emissions, limiting their effectiveness.

While neither the measures initiated in 1993 nor the additional actions developed since then and included in this report will be adequate to meet the emissions goal enunciated by the President, they have significantly reduced emissions below growth rates that otherwise would have occurred. Based on current funding levels, the revised action plan is expected to reduce emissions by 76 MMTCE in the year 2000—or 70 percent of the reductions projected in the CCAP. Annual energy cost savings to businesses and consumers from CCAP actions are anticipated to be $10 billion (1995 dollars) by the year 2000. Even greater reductions are estimated from these measures in the post-2000 period: reductions of 169 MMTCE are projected for 2010, and 229 MMTCE for 2020. Annual energy savings are projected to grow to $50 billion (1995 dollars) in the year 2010.

A separate component of this chapter addresses the U.S. Initiative on Joint Implementation. Projects undertaken through this initiative allow private-sector partners to offset emissions from domestic activities through reductions achieved in other countries. The Climate Convention established a pilot program for joint implementation at the first meeting of the Conference of the Par-

Table 1-2

Summary of Greenhouse Gas Emission-Reduction Actions

(Million Metric Tons of Carbon Equivalent)

Action Number	Action Title	1993 Action Plan Estimate 2000	Revised Estimate* 2000	2005	2010	2020
	Residential & Commercial Sector Actions	**26.9**	**10.3**	**29.4**	**53.0**	**78.4**
New	Rebuild America	2.0	1.6	3.0	6.3	7.1
1 and 2	Expanded Green Lights and Energy Star Buildings	3.6	3.3	8.4	16.3	29.9
3	State Revolving Fund for Public Buildings	1.1	Terminated			
4	Cost-Shared Demonstrations of Emerging Technologies	3.8	0.0	0.5	1.0	1.0
5	Operation and Maintenance Training for Commercial Building Facility Managers and Operators					
6	ENERGY STAR® Products	5.0	4.3	12.9	19.4	24.9
7	Residential Appliance Standards	6.8	0.2	1.8	3.7	3.8
8 and 11	Energy Partnerships for Affordable Housing	4.4	0.4	1.3	3.3	6.8
9	Cool Communities					
10	Update State Building Codes					
New	Construction of Energy-Efficient Commercial and Industrial Buildings	Not included	0.1	0.4	1.1	2.6
New	Superwindow Collaborative	Not included	0.0	0.1	0.4	1.3
New	Expand Markets for Next-Generation Lighting Products	Not included	0.2	0.4	0.7	0.9
New	Fuel Cells Initiative	Not included	0.0	0.0	0.1	0.4
	Industrial Sector Actions	**19.0**	**4.8**	**8.2**	**11.5**	**16.7**
12	Motor Challenge	8.8	1.8	3.9	5.8	7.5
13	Industrial Golden Carrot Programs	2.9	Merged into Motor Challenge (#12)			
14	Accelerate the Adoption of Energy-Efficient Process Technologies		Terminated			
15	Industrial Assessment Centers	0.5	CCAP Component Terminated			
16	Waste Minimization**	4.2	2.1	3.6	5.0	8.4
17	Improve Efficiency of Fertilizer Nitrogen Use	2.7	0.8	0.8	0.9	1.1
18	Reduce the Use of Pesticides		Terminated			
	Transportation Sector Actions	**8.1**	**5.3**	**11.5**	**15.5**	**22.1**
19	Cash Value of Parking	6.6	4.6	8.4	10.9	17.0
20	Innovative Transportation Strategies					
21	Telecommuting Program					
22	Fuel Economy Labels for Tires	1.5	0.7	3.2	4.8	5.3
	Energy Supply Actions	**10.8**	**1.3**	**3.7**	**7.0**	**18.9**
23	Increase Natural Gas Share of Energy Use Through Federal Regulatory Reform	2.2	Terminated			
24	Promote Seasonal Gas Use for Control of Nitrogen Oxides	2.8	0.5	0.0	0.0	0.0
25	High-Efficiency Gas Technologies	0.6	Terminated			
26	Renewable-Energy Commercialization	0.8	0.3	2.9	5.6	16.4
27	Expand Utility Integrated Resource Planning	1.4	Terminated			
28	Profitable Hydroelectric Efficiency Upgrades	2.0	0.0	0.0	0.0	0.0
29	Energy-Efficient Distribution Transformer Standards	0.8	0.5	0.8	1.4	2.8
30	Energy Star Distribution Transformers					
31	Transmission Pricing Reform	0.8	Terminated			
New	Green Power Network	Not Included	0.0	To be determined		

Table 1-2, continued

Summary of Greenhouse Gas Emission-Reduction Actions
(Million Metric Tons of Carbon Equivalent)

Action Number	Action Title	1993 Action Plan Estimate 2000	Revised Estimate* 2000	2005	2010	2020
	Land-Use Change & Forestry Actions***	**10.0**	**2.4**	**3.3**	**4.2**	**5.1**
43	Reduce Depletion of Nonindustrial Private Forests	4.0		Terminated		
44	Accelerate Tree Planting in Nonindustrial Private Forests	0.5	0.4	1.3	2.2	3.1
16	Waste Minimization**	4.2	2.0	2.0	2.0	2.0
9	Expand Cool Communities	0.5		To be determined		
	Methane Actions	**16.3**	**15.5**	**19.0**	**23.4**	**24.2**
32	Expand Natural Gas STAR	3.0	3.4	3.8	4.2	4.3
33	Increase Stringency of Landfill Rule	4.2	6.3	7.7	9.1	5.9
34	Landfill Methane Outreach Program	1.1	1.9	2.2	2.9	4.3
35	Coalbed Methane Outreach Program	2.2	2.6	2.9	3.2	4.0
36	RD&D for Coal Mine Methane	1.5		Terminated		
37	RD&D for Landfill Methane	1.0		Terminated		
38	AgSTAR Program	1.5	0.3	0.8	1.8	3.2
39	Ruminant Livestock Efficiency Program	1.8	1.0	1.6	2.2	2.5
	Actions to Address Other Greenhouse Gases	**16.3**	**25.4**	**40.4**	**45.8**	**54.5**
17	Improved Fertilizer Management	4.5	5.3	5.3	5.3	5.3
40	Significant New Alternatives Program	5.0	6.4	19.6	23.1	29.8
41	HFC-23 Partnerships	5.0	5.0	5.0	5.0	5.0
42	Voluntary Aluminum Industrial Partnership	1.8	2.2	2.4	2.4	2.4
New	Environmental Stewardship Initiative	Not included	6.5	8.1	10.0	12.0
	Foundation Actions+		**11.3**	**10.7**	**9.5**	**12.3**
	Climate Wise	Not estimated	1.8	2.7	3.7	4.5
	Climate Challenge++	Not estimated	7.6	5.0	1.6	1.5
	State and Local Outreach Programs	Not estimated	1.9	3.0	4.2	6.3
	Total GHG Emission Reductions From CCAP Programs	**108.6**	**76.0**	**128.3**	**169.3**	**229.5**

Notes: Several of the Climate Change Action Plan (CCAP) programs are part of larger federal efforts. These programs include Actions 2, 4, 6, 7, 15, 16, 27, 32, and 33. Only the CCAP portions of these programs are included in this table. Also, numbers may not add precisely due to interactive effects and rounding.

** There is uncertainty in any attempt to project future emission levels and program impacts, and this uncertainty becomes greater with longer forecast periods. The results of this evaluation of CCAP represent a best estimate. They are also based on the assumption that programs will continue to be funded at current funding levels.*

*** Includes Waste Wise, NICE[3], and USDA's Expansion of Recycling Technology.*

**** Additional forestry initiatives by electric utilities are included in Climate Challenge, a Foundation Program.*

+ Foundation action partners provide additional reductions in almost all sectors and gases. These values only represent incremental savings not accounted for in other actions or baseline activities.

++ For the Climate Challenge program, there is considerable uncertainty at this time in quantifying impacts beyond the year 2000, largely because partners' Climate Challenge plans do not currently extend beyond 2000. Given that participation levels are growing and that most utilities appear to be meeting or expanding upon their commitments to reducing greenhouse gas emissions, it is reasonable to expect that the Climate Challenge program will deliver more significant reductions.

ties. Guidelines for reporting under the pilot program were established by the Subsidiary Body for Scientific and Technological Advice at its fifth session in February 1997. This report uses those guidelines to report on project activity.

Impacts and Adaptability

The local and regional impacts of climate change cannot be fully determined, in part because the global models, which provide robust predictions of temperature change, do not have the capacity to resolve climate-induced damages on a local or regional scale. However, the balance of scientific evidence would suggest that even with aggressive measures to reduce global emissions, the concentrations of greenhouse gases will rise, and the climate will change. Hence, there is a need to develop appropriate adaptation responses.

Adapting to change is a challenging prospect. The impact of global change will vary greatly across geographic regions and natural and human systems, and climate change is only one of the multiple environmental stresses that policymakers and scientists must simultaneously identify and address. The Impacts and Adaptability chapter of this report discusses some of the possible impacts of and susceptibility to climate change and identifies the most important adaptation measures being explored.

All ecosystems have evolved to survive certain changes in climate and environment, with some better able to adjust than others. Adaptation can generally take place in three ways: passive adjustments (or gradual changes in behavior and tastes); deliberate reactive response (such as management responses); and anticipatory actions (planning or regulatory responses in advance of observed changes). U.S. adaptation efforts generally fall into this last category. Most were generated in an effort to increase U.S. ability to address existing threats to natural resource systems. Also, contingency planning has been used in the United States to attempt to minimize potential losses from natural disasters or accidents by preparing for such events.

The negative impacts of climate change are expected to include a rise in sea level. The 50-centimeter (20-inch) "most likely" sea level rise predicted by the IPCC from a doubling of CO_2 concentrations would inundate 10,000 square kilometers (16,667 square miles) of dry land and 8,000 square kilometers (13,333 square miles) of wetlands in the United States. While regional and local uncertainties remain, it is anticipated that global climate change would lead to changes in the hydrological cycle, including increases in storms and droughts. Although not causally linked to climate change, recent flooding of rivers in the upper Midwest of the United States have been responsible for the declaration by the President of "Federal Disaster Areas" in more than fifty counties and towns, and are consistent with the kinds of impacts associated with projected climate change scenarios. Precipitation has increased worldwide over the last century, and the proportion of rainfall in the United States falling in downpours (greater than .79 centimeters, or 2 inches a day) has increased as well. Temperature extremes are also expected to change, with heat waves (such as the one in Chicago, Illinois, in 1995 which killed 700 people) becoming more common. Changes in the patterns of infectious diseases are also anticipated and may already be occurring; for example, the combination of climate change and other ecosystem disruptions are suspected of facilitating the spread of the rodent-borne hantavirus in the American Southwest in 1992–93. Such impacts could alter the ranges for certain species of common agricultural crops, as well as modifying unmanaged ecosystems.

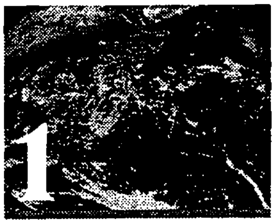
To anticipate and respond to such environmental threats, the President signed an Executive Order establishing the National Science and Technology Council's Committee on Environment and Natural Resources. The Committee coordinates all environmental research, including global climate change and biodiversity, using subcommittees to ensure that the individual strengths of all involved agencies are effectively used. Various pieces of legislation have also been enacted to address natural resource management and adaptation—among them, the Energy Policy Act of 1992, the Federal Coastal Zone Management Act, and the 1996 Federal Agricultural Improvement and Reform Act (which includes the Conservation Reserve Program). However, because of the uncertainties inherent in predicting climate changes at the local and regional levels, work on understanding the impacts from and adaptation to the effects of climate change will remain a high priority for years to come.

Research and Systematic Observation

The U.S. government has dedicated significant resources to research on global climate change. U.S. research efforts (some of which include the private sector) are divided into several general categories, including prediction of climate change, impacts and adaptation, mitigation and new technologies, and socioeconomic analysis and assessment. In addition, U.S. scientists actively coordinate with research and capacity-building efforts in other countries.

The principal vehicle for undertaking climate change research at the federal level is the United States Global Change Research Program. The multiagency program was funded in fiscal year 1997 at approximately $1.8 billion. A significant portion of the Research Program's activities is targeted at improving capabilities to predict climate change, including the human-induced contribution to climate change, and its implications for society and the environment. The United States also is committed to continuing programs in research and observation, with the aim of developing the information base required to improve predictions of climate change and its repercussions, as well as the ability to reduce emissions while sustaining food production, ecosystems, and economic development.

Extensive efforts also are being made to understand the consequences of climate change, regional impacts, and the potential for adaptation. Another area being explored by researchers is the development of technologies that would enable the United States to supply energy, food, water, ecosystem services, and a healthy environment to U.S. citizens, while simultaneously reducing greenhouse gas emissions. These efforts have been divided into short- and longer-term projects involving the private sector, as well as government-sponsored research.



Perhaps most notable in the international component of the research effort is U.S. participation in IPCC work. U.S. scientists participated in the preparation and review of nearly all of the more than 100 chapters of the over 2,000-page report. Researchers also participated in the collection and analysis of the underlying data through programs as varied as the World Climate Research Program, the Human Dimensions of Global Environmental Change Program, the International Geosphere–Biosphere Programme and a staggering array of bilateral scientific and technical work.

Education, Training, and Outreach

Global climate change education, training, and outreach are intrinsically interwoven with the latest in technology and scientific discoveries. The Education, Training, and Outreach chapter highlights representative programs in each of these areas.

That training and education are critical is self-evident. The engagement of future generations of scientists will be integral to the nation's understanding of climate change and the possible mitigation of its effects. The education and training of today's citizens and leaders will enable informed choices to be made in the current policy environment and will help to provide the means to implement proposals when they are adopted.

The U.S. program includes a strong education component. Federal legislation over the past several years has led to the funding of important programs related to climate change, including the creation of teaching materials, resource guides, and fact sheets, which are widely distributed both nationally and internationally. Students are encouraged to join special sessions that foster the development of theoretical and applied engineering skills, and the growth in the number of doctoral and postdoctoral students in fields related to climate change has been significant.

Outreach activities disseminate information about global climate change, its impact, and the need for behavioral changes to the widest possible audience. Effective messages can be communicated both directly (e.g., through global climate change exhibits at museums) and indirectly (through outreach programs created by public–private partnerships, such as incentives for fuel-efficient vehicle purchases).

The U.S. government supports a number of Internet sites on climate change, the regular holding of roundtables and public workshops and seminars at which climate change and mitigation actions are described, and an extensive state and local outreach effort. Nongovernmental organizations and the press are also crucial to U.S. outreach efforts. Each plays a pivotal role in helping to inform the public about the climate change problem and possible solutions.

The links between these topics and the more specific policies and measures being taken to mitigate climate change are clear. The United States must have educated citizens and decision makers to develop and establish new policies. It must have training to implement climate programs and policies. And it must have outreach programs to help inform its citizens about the consequences of both action and inaction and to help policymakers decide whether and how to train and educate the next generation of citizens.

International Activities

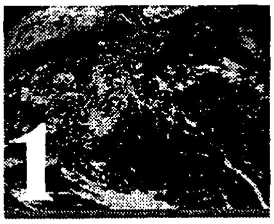
No single country can resolve the problem of global climate change. Recognizing this, the United States is engaged in many activities to facilitate closer international cooperation. To this end, the U.S. government has actively participated in international research and assessment efforts (e.g., through the IPCC), in efforts to develop and implement a global climate change strategy (through the FCCC Conference of the Parties and its varied subsidiary bodies and through the Climate Technology Initiative), and by providing financial and technical assistance to developing countries to facilitate development of mitigation strategies (e.g., through the Global Environment Facility (GEF)). Bilateral and multilateral opportunities are currently being explored, with some designed to capitalize on the technological capabilities of the private sector, and others to work on a government-to-government basis.

In the existing Convention framework, the United States has seconded technical experts to the FCCC secretariat to help implement methodological, technical, and technological activities. U.S. experts review national communications of other Parties and are helping to advance the development of methodologies for inventorying national emissions.

The United States has been active in promoting next steps under the Convention. It has encouraged all countries to take appropriate analyses of their own circumstances before taking action—and then act on these analyses. It has suggested—and, where possible, has demonstrated—flexible and robust institutional systems through which actions can be taken, such as programs to implement emission-reduction activities jointly between Parties, and emission-trading programs. The United States has also sought to use its best diplomatic efforts to prod those in the international community reluctant to act, seeking to provide assurances that the issue is critical and warrants global attention. Through these efforts, the ongoing negotiations are expected to successfully conclude in late 1997. The successful implementation of the Convention and a new legal instrument will ensure that the potential hazards of climate change will never be realized.

As a major donor to the GEF, the United States has contributed approximately $190 million to help developing countries meet the incremental costs of protecting the global environment. Although the United States is behind in the voluntary payment schedule agreed upon during the GEF replenishment adopted in 1994, plans have been made to pay off these arrears.

The principles of the U.S. development assistance strategy lie at the heart of U.S. bilateral mitigation projects. These principles include the concepts of conservation and cultural respect, as well as empowerment of local citizenry. The U.S. government works primarily through the U.S. Agency for International Development (USAID). In fact, mitigation of global climate change is one of USAID's two global environmental priorities. Other climate change-related government agencies, including the Environmental Protection Agency and the Departments of Agriculture and Energy, are also active internationally. Projects fit into various general categories, such as increasing the efficiency of power operation and use, adopting



renewable-energy technologies, reducing air pollution, improving agricultural and livestock practices, and decreasing deforestation and improving land use.

Perhaps none of the U.S. programs is as well known—or as effective internationally in furthering the implementation of the Climate Convention—as the U.S. Country Studies Program. The program is currently assisting fifty-five developing countries and countries with economies in transition to market economies with climate change studies intended to build human and institutional capacity to address climate change. Through its Support for National Action Plans, the program is preparing national climate action plans for eighteen countries, which will lay the foundation for their national communication, as required by the FCCC. More than twenty-five additional countries have requested similar assistance from the Country Studies Program.

The United States is also committed to facilitating the commercial transfer of energy-efficient and renewable-energy technologies that can help developing countries achieve sustainable development. Under the auspices of the Climate Technology Initiative, the U.S. has taken a lead role in a task force on Energy Technology Networking and Capacity Building, the efforts of which focus on increasing the availability of reliable climate change technologies, developing options for improving access to data in developing countries, and supporting experts in the field around the world. The United States is also engaged in various other projects intended to help countries with mitigation and adaptation issues. The International Activities chapter focuses on the most important of these U.S. efforts.

The Future

Overall, the conclusions to be drawn from this report can be summarized in three parts:

- Climate change is a clearly defined problem and is well recognized at the highest levels in the U.S. government. Senior officials (from the President to heads of cabinet agencies and departments) have taken a strong stand in favor of seeking to reduce emissions.
- The combined effort to address climate change (described in this report, and including the Research Program, the total costs of U.S. mitigation actions, and the international effort) are in excess of $2 billion—a significant step by any standard.
- Notwithstanding this effort, emissions continue to grow. More aggressive actions must be taken to combat the threat of climate change.

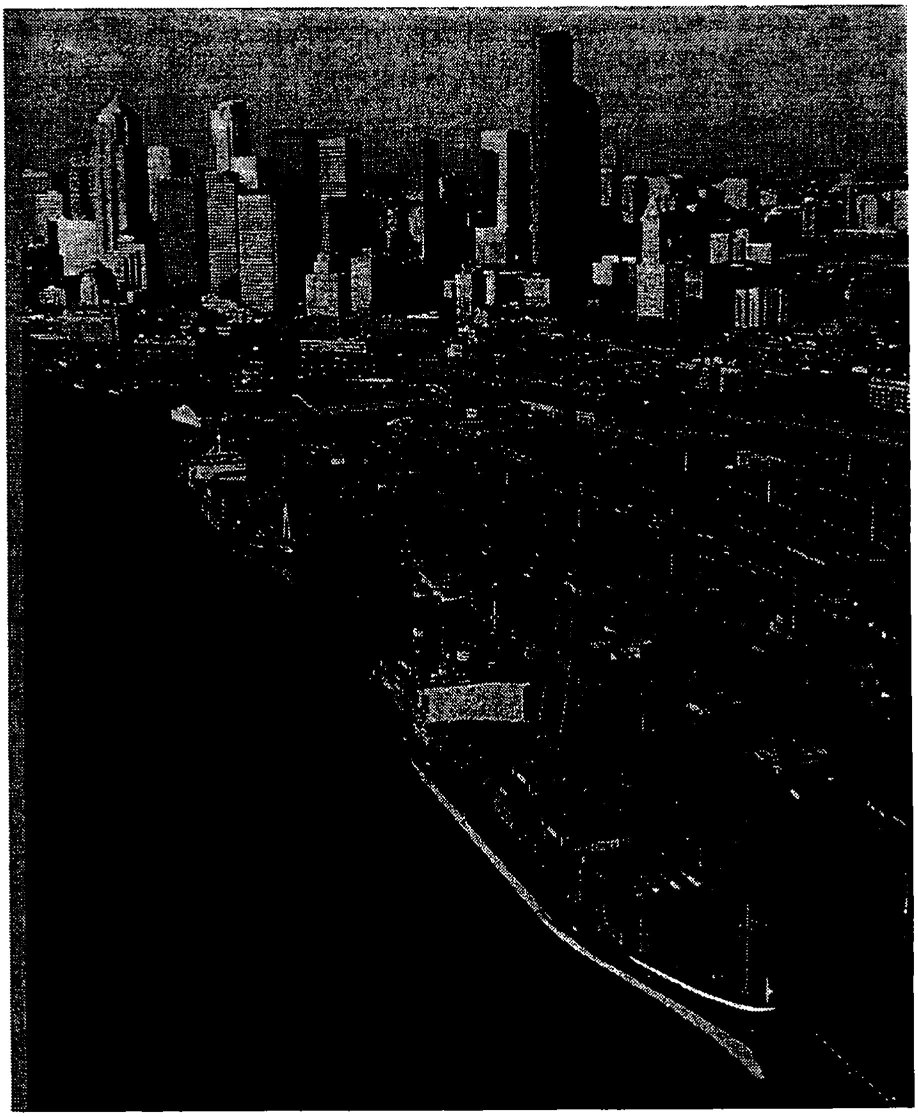
The United States is developing a long-term, post-2000 strategy to address the climate change problem. This effort, which has both a multilateral, international focus and a domestic focus, is expected to be made public in the next few months. It will be based on an extensive analytic effort to assess the effects of an array of additional policy choices, including setting legally binding, internationally agreed caps on emissions. It will consider the advantages of market-based instruments for both domestic and international emissions trading, as well as joint implementation for credit with developing countries. It will consider approaches to be taken for gases for which monitoring and measurement are relatively simple (e.g., for carbon dioxide emissions from stationary energy sources), as well as those gases for which emissions are more difficult to measure (such as nitrous oxides from agriculture).

Currently underway, the effort is intensive and time-consuming. It involves more than twenty agencies within the federal government, as well as several offices in the Executive Office of the President. Congress will be consulted in the development of policies and will most likely need to enact legislation to implement any agreed program. A significant stakeholder outreach program will be undertaken over the next several months to engage the best thinking on alternative approaches, and following adoption of a program to ensure maximum compliance with the course of action chosen.

As of today, the effort is not complete; analyses are still underway. However, as Benjamin Franklin, a great American eighteenth-century statesman, said in his autobiography:

> I have always thought that one ... may work great changes, and accomplish great affairs among mankind, if [one] first forms a good plan ... [and] make[s] the execution of that same plan [one's] sole study and business.

The United States is in the planning process. It hopes this effort will yield the great changes in both the U.S. domestic emissions path and, by example, the global emissions path, that may be needed to ensure global concentrations of greenhouse gases do not rise to—and beyond—dangerous levels.

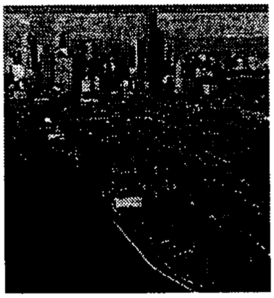


As the U.S. demand for energy services rises with expanded U.S. economic growth, associated greenhouse gases emissions are increasing accordingly, particularly in the agricultural and industrial sectors. However, over time economic growth tends to spur improvements in energy efficiency, thus reducing emissions per unit of gross domestic product (GDP).

U.S. climate, geography, land use, and population patterns heavily influence the nation's energy needs and, hence, emissions of greenhouse gases. U.S. governmental, economic, and societal structures affect how the nation responds to the climate challenge. In addition, all these factors affect the nation's vulnerability to climate change and its ability to adapt to a changing climate.

Global climate change presents unique challenges and opportunities for the United States. This chapter explains the national circumstances of the United States as they relate to climate change: historical developments, current conditions and trends in those conditions, and their link to climate change issues and policymaking.

national circumstances



U.S. Climate and Natural Resources

The United States has a wide variety of climate conditions, representative of all the major regions of the world, except the ice cap. In the North, heating needs dominate cooling needs, while the reverse is true in the South. As Figure 2–1 shows, some U.S. regions experience extreme temperatures in both summer and winter. The number of heating- and cooling-degree days—and resulting energy needs—can fluctuate dramatically from year to year.

Because of this broad diversity, describing the effects of climate change on the United States as either positive or negative overall would be an oversimplification. For example, states with cooler climates might see some benefits from global warming, such as extended growing seasons and lower heating bills, although other potential consequences, such as increased risk of drought and disruptions to ecosystems, could offset these benefits. In the Sunbelt, on the other hand, energy consumption for cooling and associated emissions would be expected to rise significantly.

Baseline rainfall levels also vary significantly by region, with most of the western states being very arid. The reduced rainfall and increased evaporation from global warming projected for the mid-continental areas of the United States by general circulation models could exacerbate regional scarcity of freshwater resources. Although the eastern states have only rarely experienced severe drought, they are increasingly vulnerable to flooding and storm surges—particularly in increasingly densely populated coastal areas—as sea level rises. In recent years, insurance losses from tornadoes, floods and tropical storms have increased. If extreme weather events of this kind were to occur with greater frequency or intensity, as some climate models predict, damages could be extensive.

The diverse U.S. climate zones, topography, and soils support many ecological communities and supply renewable resources for many human uses. The nature and distribution of these resources have played a critical role in the development of the U.S. economy, thus influencing the pattern of U.S. greenhouse gas emissions.

Land Resources

The United States has a total land area of 916 million hectares (2.3 billion acres). Of the 766 million hectares (1.89 billion acres) in the conterminous states, about 77 percent is privately held, the federal government owns about 21 percent, and state or local governments own the remaining 2 percent. In Alaska, by contrast, the federal government owns 66 percent of the state's 149 million hectares (368 million acres), the state government owns 24 percent, and Native

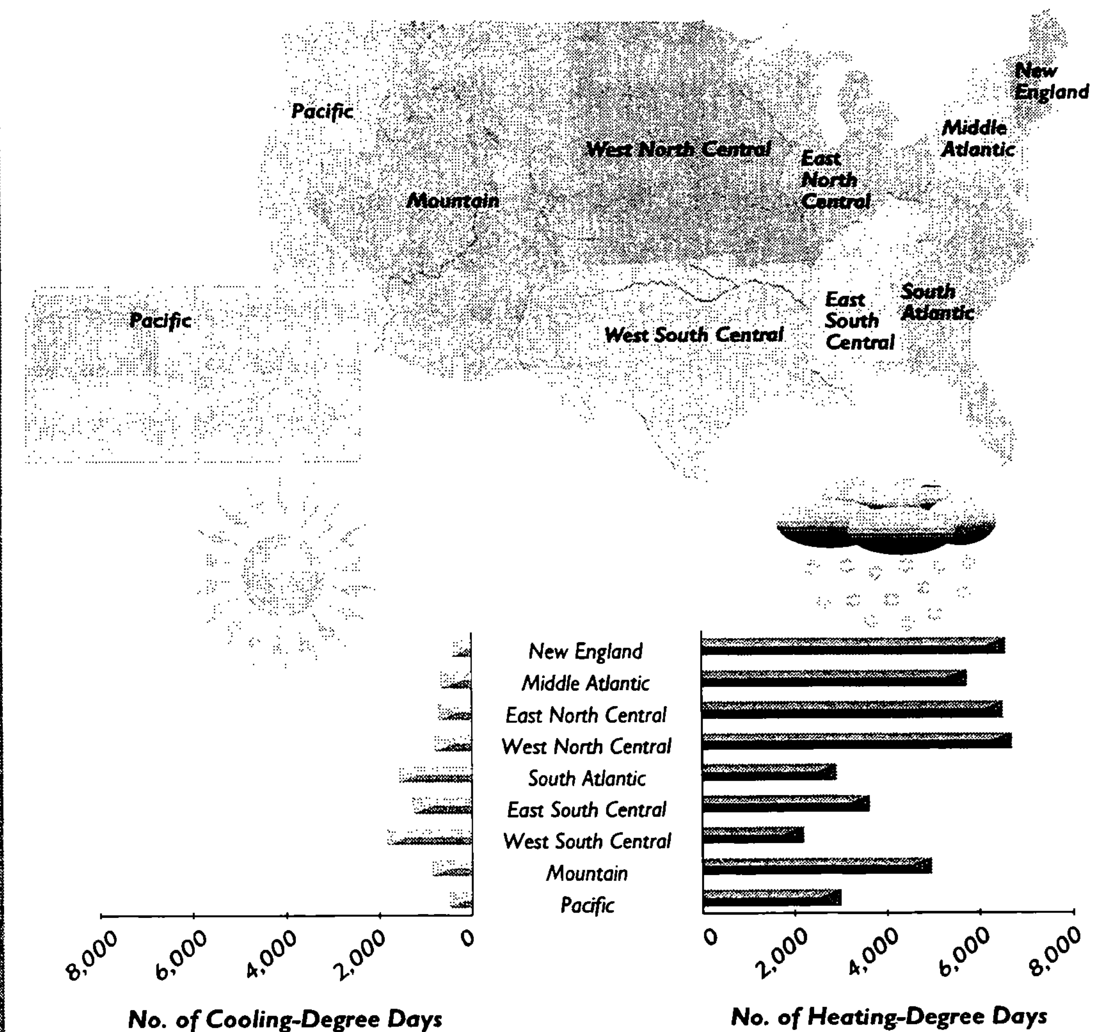
Americans own 9.7 percent; only 400,000 hectares (1 million acres) are privately held.

Although the private sector has played a primary role in developing and managing U.S. natural resources, federal, state, and local governments have also been important in managing and protecting these resources through regulation, economic incentives, and education. Governments also manage lands set aside for forests, parks, wildlife reserves, special research areas, recreational areas, and suburban/urban open spaces.

Figure 2-1

1995 Heating- and Cooling-Degree Days in the U.S.

While regions with cooler climates may benefit from global warming because of reduced demand for heating, energy consumption for cooling may rise in regions with warmer climates, along with the emissions it generates.



Source: U.S. DOE/EIA 1996a

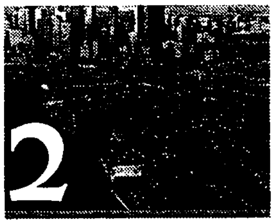


Table 2–1 shows how U.S. land resources were distributed in 1992. Total forest land comprised 29 percent of the U.S. landscape, or 33 percent if land in parks and other special uses are included. The proportions of total land area are significantly affected by the land area of Alaska, which has very little cropland pasture (0.5 million hectares, or 0.3 percent) but large areas of forest-use, special-use, and miscellaneous other land (147 million hectares, or 99.6 percent).

Forests

Forest land offers a significant sink for greenhouse gases but may also be highly vul-

Table 2-1

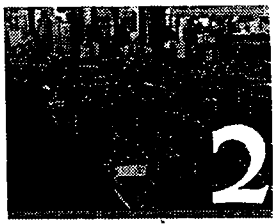
U.S. Land Use: 1992

The United States is the world's fourth largest country. Nearly 30 percent of its territory is covered in forests, while approximately 20 percent is devoted to cropland.

Land Use	Land Area (in millions) Hectares	Land Area (in millions) Acres	Percent of Total Land Area
Forests Total forested land, as classified by the U.S. Forest Service, excluding an estimated 36 million hectares (79.2 million acres) used primarily for parks and wildlife areas.	**262**	**576.4**	**28.6**
Pasture and Range Permanent grassland and other nonforested pasture and range.	**239**	**525.8**	**26.1**
Cropland All land in the crop rotation, including land used for crops, land left idle, and land used for pasture.	**186**	**409.2**	**20.3**
Special Uses Rural transportation areas, areas used primarily for recreation and wildlife purposes, various public installations and facilities, farmsteads, and farm roads, including approximately 36 million hectares (79.2 million acres) that overlap with forest land.	**114**	**250.8**	**12.4**
Other Uses Includes urban areas; areas in miscellaneous uses not inventoried; and marshes, open swamps, bare-rock areas, desert tundra, and other land generally having low value for agricultural purposes.	**114**	**250.8**	**12.5**
Total Land Area*	**916**	**2,015.2**	**100.0**

* *Includes streams; canals narrower than 1/6 of a kilometer (about 1/8 of a mile); and ponds, lakes, and reservoirs covering less than 16 hectares (35.2 acres).*

Source: USDA/ERS 1995



nerable to changes in the climate system and in forest management practices. U.S. forests vary from the complex juniper forests of the arid interior West to the highly productive forests of the Pacific Coast and the Southeast. Forest land has increased since the 1960s, from 251 million hectares to 298 million hectares in 1992. Of this 1992 forest land, 198 million hectares were timberland, most of which is privately owned.

Management inputs over the past several decades have been gradually increasing production of marketable wood in U.S. forests. The United States currently grows more wood than it harvests, with a growth-to-harvest ratio of 1.37. This ratio reflects substantial new forest growth; old-growth forests have continued to decline over the same period.

Grazing Lands

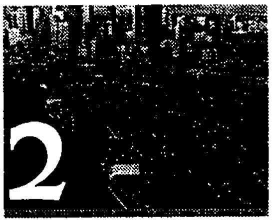
Grazing lands, including both grassland pasture and range and cropland pasture, are environmentally important to the United States. They are the single largest land use, have the potential to absorb significant quantities of greenhouse gases, include major recreational and scenic areas, serve as a principal source of wildlife habitat, and comprise a large area of the nation's watersheds. These ecosystems, like forest ecosystems, are vulnerable to rapid changes in climate, particularly shifts in temperature and moisture regimes. Range ecosystems are more resilient than forest ecosystems, however, because of their ability to sustain long-term droughts.

Grassland pasture and range ecosystems are any of a number of different communities usually denoted by the dominant vegetation. They are generally managed by varying grazing pressure, using fire to shift species abundance, and by occasional disturbance of the soil surface to improve water infiltration. Cropland pasture, in contrast, is a grazing ecosystem that relies on more intensive management inputs, such as fertilizer, chemical pest management, and introduced or domesticated species. Range and grassland pasture accounts for 239 million hectares (591 million acres), while cropland pasture accounts for 27 million hectares (68 million acres). U.S. cropland pasture includes native grasslands, savannas, alpine meadows, tundra, many wetlands, some deserts, and areas seeded to introduced and genetically improved species.

The total area of pasture and range consistently declined from 1949 through 1987 (from 283 to 264 million hectares, or 699 to 652 million acres), with a small increase estimated for 1992 (265 million hectares, or 655 million acres). Most of this land was probably converted to urban or suburban land uses. The reasons for the decline in forested grazing lands are decreasing demand for livestock, as reflected in static prices for animals and animal fiber; conversion to shorter-rotation forests, which have reduced the quality of available forage; and reduced grazing on hilly terrain due to the resulting vulnerability to soil erosion.

Approximately 13 million hectares (32 million acres) of range and pasture are still in a highly erodible state due to sheet and rill erosion, and an additional 15 million hectares (37 million acres) are highly erodible due to wind erosion. The general condition of grazing lands, both range and pasture, has been improving over the past twenty years.

Climate change would most likely decrease the productivity of these lands, but



could actually benefit their overall ecological condition. The warmer and drier conditions projected for the mid-continental areas might adversely affect these lands at first. As extreme drought continued, however, lack of easily available water would result in reduced grazing, which would allow the land to recover.

Agricultural Land

The United States enjoys a natural abundance of productive agricultural lands and a favorable climate for producing food crops, feed grains, and other agricultural commodities, such as oil seed crops. The area of U.S. cropland used for crops has declined by 12 percent in the past decade from 155 million to 136 million hectares (from 383 million to 336 million acres), as conservation programs for the most environmentally sensitive lands and highly erodible lands have removed 14 million hectares (35 million acres) from cropping systems.

Although the United States harvests about the same area as it did in 1910, it feeds a population that has grown two and a half times since then, and its food exports have expanded considerably. The regional effects of climate change will vary, with studies finding that the net economic impacts on U.S. agriculture associated with a doubling of atmospheric CO_2 could be positive or negative. Most studies show that the southern part of the country will be more severely affected than other regions. The impacts of climate variability, adjustment costs, shifts in pest distributions, changes in water available for irrigation, and the interactions with other environmental and economic stresses have not been adequately addressed in assessment

Federal Agricultural Improvement and Reform Act of 1996

The "FAIR" Act has significantly changed U.S. agricultural policy. It decouples income support payments and commodity prices by providing for annual fixed but declining "production flexibility payments" for the period 1996–2002. Participating farmers have much greater flexibility to make planting decisions. They may plant any crop on contract acres, with limitations on fruit and vegetables. Unlimited haying and grazing and alfalfa production are also permitted. As a result, producers will rely more heavily on market signals and can adapt more readily to environmental changes.

Farmers continue to have an opportunity to enroll their environmentally sensitive land in the Conservation Reserve Program (CRP) and receive annual rental payments for taking the land out of crop production and for maintaining specific conservation practices. Farmers participating in the federal farm programs must implement conservation plans to protect their soils and wetlands. These conservation measures reduce soil erosion, improve water quality, enhance wildlife habitat, and increase carbon sequestration in the soil.

Under the 1996 Farm Bill, tree planting will continue under the CRP, and with cost-share assistance in the Forestry Incentives Program, the Stewardship Incentive Program, and the Environmental Quality Incentives Program (EQIP). Tree planting under cost-share programs has averaged about 121,408 hectares (300,000 acres) per year, but this is expected to decline in response to lower levels of federal funding. For the first time, environmental concerns related to animal agriculture will be addressed through cost-share assistance under the EQIP.

studies. Experimental results suggest that the direct effects of a doubling of atmospheric CO_2 (the CO_2 "fertilization effect") under ideal growing conditions are increases in yields of 4–5 percent for C4 crops, such as corn, sugar cane, and sorghum, and 15–20 percent for C3 crops, such as wheat, soybeans, and rice.

Between 1947 and 1989, the total output of livestock and livestock products rose 1.8 times, while during the same period production per unit of breeding stock rose 2.2 times. The total number of cattle peaked at 132 million head in 1975 and declined to 100 million head in 1992. Similarly, sheep numbers decreased from 8.5 million head in 1977 to 7.7 million head in 1992. These statistics reflect the significant decline in average beef and lamb consumption per capita in recent years.

Ruminant animals, such as cattle, and the breakdown of livestock manure are significant sources of methane, a major contributor to global warming. Although the number of cattle and sheep has been declining, methane emissions from agricultural activities have been steadily rising.

Wetlands

Wetland ecosystems are some of the more biologically important and ecologically significant systems on the planet. Because they represent a boundary condition ("ecotone") between land ecosystems and aquatic ecosystems, wetlands have many functions. They provide habitats for many types of organisms, both plant and animal; serve as diverse ecological niches that promote preservation of biodiversity; are the source of economic products for food, clothing, and recreation; trap sediment, assimilate pollution, and recharge ground water; regulate water flow to protect against storms and flooding; anchor shorelines; and prevent erosion. A wide variety of wetland types exists in the United States, ranging from permafrost-underlain wetlands in Alaska to tropical rainforests in Hawaii.

Because wetland ecosystems are highly dependent upon upland ecosystems, they are vulnerable to changes in the health of the upland ecosystems as well as to environmental change brought about by shifts in climate regimes. Wetlands, including riparian zones along waterways and areas of perennial wet soils or standing water, are both sources of and sinks for greenhouse gases.

Since the nation's settlement in the eighteenth century, the continental United States has lost 47.4 million hectares (117 million acres) of its original 89.5 million hectares (221 million acres) of wetlands. Agricultural uses accounted for about 54 percent of wetland losses since the colonial period of U.S. history. A significant additional share of wetlands was lost as a result of federal flood control and drainage projects.

The pace of wetland loss has slowed considerably in the past two decades, since the implementation of government policies to protect wetlands. For example, while net wetland losses from the mid-1950s to the mid-1970s averaged 185,400 hectares (458,000 acres) a year, they fell to about 117,400 hectares (290,000 acres) a year from the mid-1970s to mid-1980s. The reduced rate of wetland loss since the mid-1980s is attributable both to government policies for protecting wetlands and to low crop prices, which have reduced conversions of wetlands to

agricultural uses. Future losses are likely to be even smaller, as the United States has implemented a "no net loss" policy for wetlands.

Alaska's 69 million hectares (170 million acres) of wetlands easily exceed the 42 million hectares (104 million acres) of wetlands in the continental United States. Many of these areas are federally owned, although precise figures are not available. Total wetland losses in Alaska have been less than one percent since the mid-1800s, although in coastal areas they have been higher.

Wildlife Resources

During the past twenty years, the United States has become more aware of the reduction in the diversity of life at all levels, both nationwide and worldwide. Warmer climate could exacerbate this trend, for example, by causing the dieback of vegetation essential to the habitat of particular species. To better understand and catalog both previous and future changes, the United States has begun a comprehensive, nationwide survey of its wildlife and biodiversity, called the National Biological Survey.

Information on endangered species is already available through other sources. As of April 1997, 850 species were listed as endangered, of which 518 are plants and 332 are animals. An additional 105 plant and 116 animal species were listed as threatened, for a total of 1,071 threatened or endangered species.

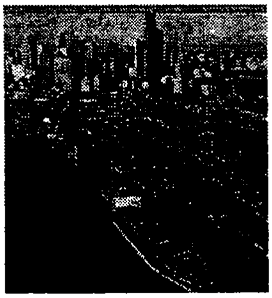
Water Resources

The development of water resources has been key to the growth and prosperity of the United States. Abundant and reliable water systems have enabled urban and agricultural centers to flourish in arid and semi-arid regions of the United States. For instance, between 1954 and 1992, irrigated agricultural land more than doubled, from 12 million hectares (29 million acres) to 25 million hectares (62 million acres).

Currently, most of the nation's freshwater demands are met by diversions from streams, rivers, lakes, and reservoirs and by withdrawals from ground-water aquifers. Even though total withdrawals of surface water more than doubled from 1950 to 1980, withdrawals remained less than 21 percent of the renewable supply in 1980. However, some areas of the country still experience intermittent water shortages during droughts.

In the arid sections of the western United States, there is increasing competition for water, not only from traditional agricultural and hydropower sources, but also for drinking water in growing urban areas; for American Indian water rights; and for industry, recreation, and natural ecosystems. The flows of many streams in the West are fully allocated to current users, limiting opportunities for expanded water use by major new facilities. Recently enacted state legislation adopts a market-based approach to water pricing and allocation, thus offering the potential to alleviate projected shortfalls. Also pertinent is the federal government's insistence that certain minimum-flow requirements be met to preserve threatened and endangered species.

Potential climate changes, including changes in the periodicity and frequency of precipitation and rising temperatures, may have a significant effect on water resources and resource infrastructure.



U.S. Population Trends

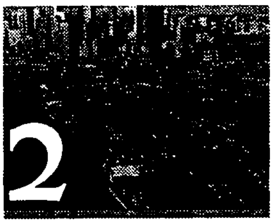
Population levels and growth drive a nation's consumption of energy and other resources, as more people require more energy services. However, low population density means higher emissions per capita, as transportation needs and housing sizes are greater where people live farther apart. Settlement patterns and population density also affect the availability of land for various uses, and the vulnerability of coastal populations to flooding in the event of sea level rise.

With a population of just over 265 million in 1996, the United States is the third most populous country in the world, after China and India. U.S. population density, however, is relatively low (Figure 2–2), resulting in higher transportation needs and larger houses. Population density also varies widely within the United States, and those patterns are changing as people not only move from rural to metropolitan areas, but also move from denser city cores to surrounding suburbs. The result is a greater reliance on private automobiles for transportation, leading to increased congestion and emissions from motor vehicle use.

Overall, U.S. population growth has slowed to about one percent per year, which is still high by OECD standards (about twice the rate for the European Union, and four to five times the rate in Japan). Of this one percent, net immigration contributes about 0.3 percent of population growth, and natural increase (births minus deaths) the remaining 0.7 percent.

The U.S. population is aging rapidly—the current median age is 34.5 years, compared to 33.1 in 1994 and 28 in 1970. This results both from increased life expectancy, which now stands at 76 years, and from reduced fertility rates. With these population trends has come a steady reduction in average household size, as people marry later, have fewer children, are more likely to divorce, and are more likely to live alone as they age. Thus, while the population has grown by about 27 percent since 1970, the number of households has grown much more rapidly—by 57 percent. Even as household size has declined, the average heated floor space per household has increased by 5.6 percent, from 1,624 square feet for dwellings built in 1979 or earlier, to 1,716 square feet for those built between 1980 and 1993.

The geographic distribution of the population has significant implications for climate change, in terms of both vulnerability and emissions. First, more and more people are moving to the drier, warmer climates of the Sunbelt in the South and Southwest. Populations in most of the nation's coastal areas are growing rapidly. As a result, more people will be vulnerable to the potential effects of climate change.

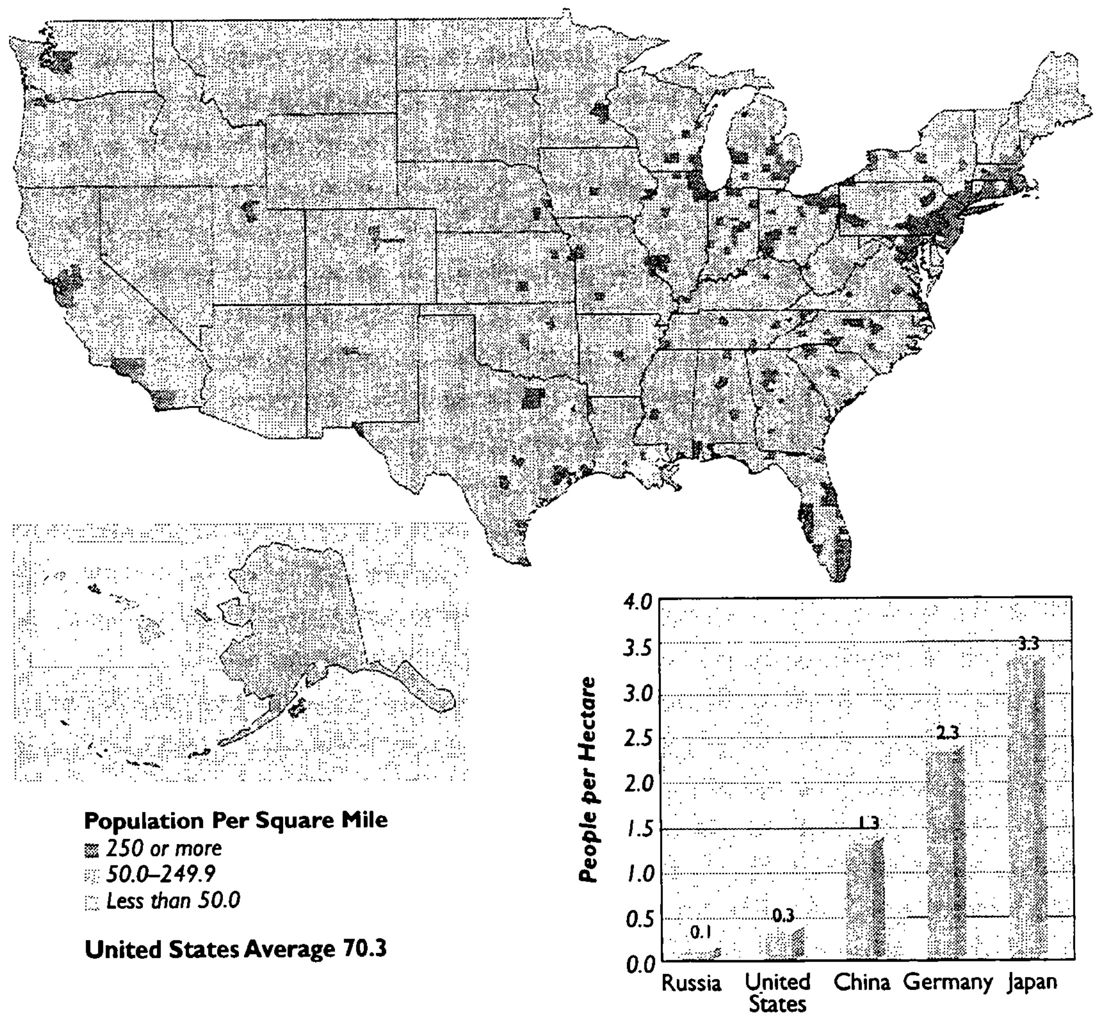


This pattern of growth has resulted in over 50 percent of the population living in metropolitan areas with more than one million people, up from 29 percent in 1950. However, this growth has been concentrated in suburbs, rather than in city centers. In fact, most major cities have experienced population declines, as crime, congestion, higher taxes, and the need for better schools have led people to move to the suburbs. As a result, population densities in U.S. metropolitan areas are far lower than in metropolitan

Figure 2-2

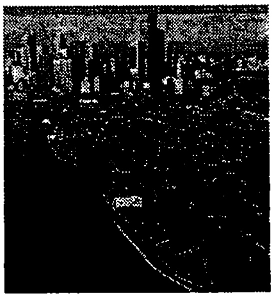
U.S. Population Density

Though the United States is the third most populous country in the world, after China and India, U.S. population density is relatively low. Some related energy-consuming implications include long distances for domestic freight shipments, high individual premiums placed on "elbow room," and local and regional zoning that promotes automobile travel.



Sources: U.S. DOC/ESA/Census 1995, WRI 1994, and World Bank 1996 areas around the world, and they continue to decline. For example, the ten largest European cities on average have population densities four times greater than the ten largest U.S. cities. The relatively low densities in the United States result in relatively high energy use per capita.

Another factor leading to higher emissions is the increasing mobility of the U.S. population. The average U.S. citizen has moved eleven times in his or her lifetime. According to the 1990 census, 38 percent of U.S. residents do not live in the state where they were born—up from 31 percent in 1980 and 26 percent in 1970. Families are often dispersed across the country. It is not uncommon for people to move across the country for education, career, or personal reasons. All of these factors lead to an ever-growing need for transportation services.



The U.S. Economy

The combination of a large and dynamic population, bountiful land and other natural resources, and vibrant competition in a market economy make the U.S. economy the largest in the world, with a GDP of over $7 trillion in 1997 dollars, or 22 percent of the global economy.

Government and the Market Economy

Several principles, institutions, and technical factors have contributed to the evolution of the U.S. market economy. The first of these is the respect for individual rights, especially the right to own and use private property to one's own advantage. The U.S. economic system is also underpinned by a reliance on market forces, as opposed to tradition or force, as the most efficient means of organizing economic activity. Put another way, in a well-functioning market, relative prices should be the primary basis on which economic agents within the U.S. economy would make decisions about production and consumption. Ideally, the price system, combined with a system of well-defined and well-protected private property rights, allocates the resources of the U.S. economy in a way that produces the greatest possible social welfare.

Markets do not always function perfectly, however. For example, the production of some goods and services creates costs or benefits (externalities) that the price system does not capture. If the production of a good has environmental costs that are not borne directly by its producers or consumers, that product may be priced too low, stimulating excess demand. Alternatively, research and development (R&D) may produce benefits to society beyond those that accrue to the firm doing the research, but if those benefits are not captured in the price, firms will underinvest in R&D.

In such cases, the U.S. government sometimes intervenes to alter the allocation of resources. Government intervention may include limiting the physical quantity of pollution that can be produced, or charging polluters a fee for each unit of pollution emitted. As a practical matter, however, accurately establishing the cost of the externality to internalize it by a fee, a tax, or a regulation can be very difficult. There also is a risk that government intervention could have other, unintended consequences. For these reasons, the U.S. government tends to be cautious in its interventions. The U.S. government, however, does take actions necessary to protect human health, the environment, and natural resources.

In addition, many government interventions are intended to facilitate or support well-functioning markets. By protecting

property rights, producing public goods such as roads and other types of infrastructure, internalizing external costs, and promoting a minimum standard of living for all of its citizens, the U.S. government fosters an environment in which market forces can operate. Finally, government inevitably influences the economy as regulatory and fiscal processes affect the functioning of markets.

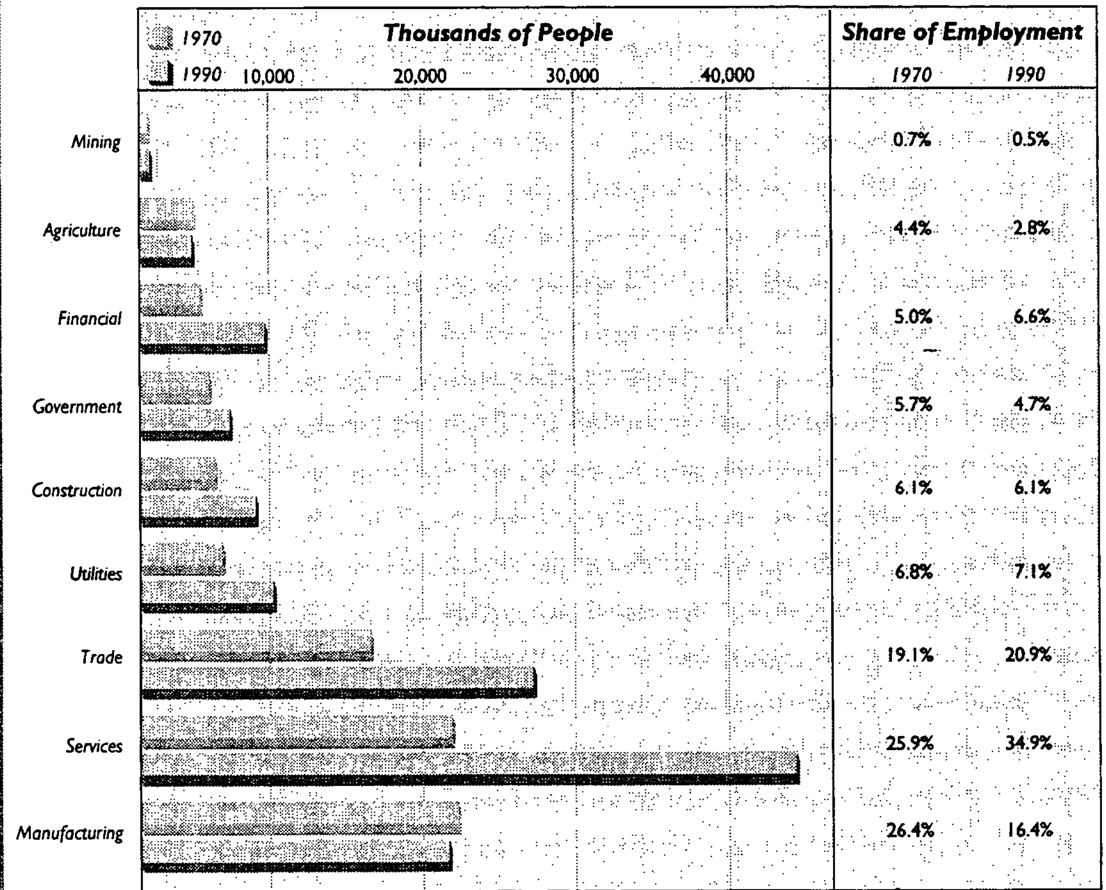
Composition and Growth

The willingness of policymakers, the business community, and the public to tackle more long-run and strategic environmental issues, such as climate change, is to a large extent dependent on the health of the economy. A robust economy encourages this type of forward thinking, as concerns about unemployment and growth lessen. At the

Figure 2-3

U.S. Employment by Industry

Between 1970 and 1994, employment in the financial, construction, utilities, trade, and services sectors rose dramatically. Today, the service sector employs more than one-third of the U.S. population.



Source: U.S. DOE/ESA/Census 1996

same time, robust economic growth typically leads to higher emissions of greenhouse gases.

From 1960 to 1993, the U.S. economy grew at an average annual rate of 3 percent, raising real GDP from nearly $2 trillion to over $5 trillion (in 1987 dollars). With population growth averaging 1.1 percent over the same period, this meant an annual increase of 1.8 percent in real GDP per capita, from $10,903 in 1960 to $19,874 in 1993 (in 1987 dollars). Employment over this period almost doubled, from 65 million to 120 million, as the influx of women into the work force raised overall labor force participation from 59 percent to 66 percent.

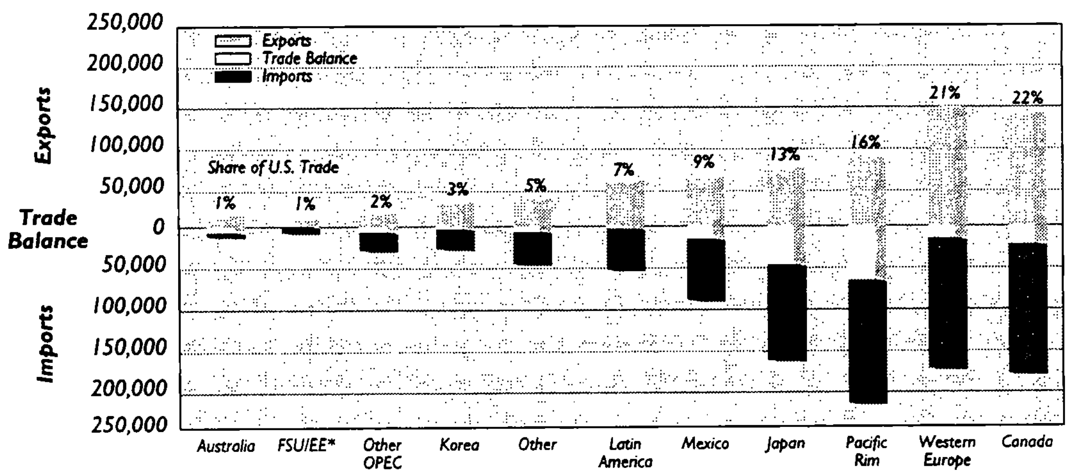
This rapid growth has been led by the service sector (which includes communications, utilities, finance, insurance, and real estate), whose share of the economy has nearly tripled since 1960. Meanwhile, employment in industries with more direct cause or effect links to the climate change issue (agriculture, mining, forestry, and fisheries) has declined substantially (Figure 2–3).

After several years of anemic growth in the early 1990s, the U.S. economic expansion consolidated in 1993, setting the stage for moderate but sustainable economic growth of 2.5 to 3 percent per year over the mid-1990s. This growth has reduced unemployment to about 5.6 percent in 1995, while producing healthy increases in real disposable income and increased real wages. The higher levels of economic activity and consumer spending associated with this renewed economic growth have contributed to higher rates of energy consumption and associated CO_2 emissions.

Figure 2-4

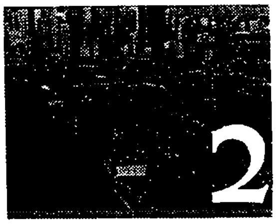
U.S. International Trade

While most if its trade is with other developed countries, the United States has the biggest deficit in rapidly growing trade with he developing countries of Asia.



* Former Soviet Union/Eastern Europe

Source: U.S. DOC 1997



The increasing U.S. dependence on international trade has heightened concerns about the effects of emission-reduction policies on competitiveness. While most U.S. trade is with other OECD countries, trade with the rapidly developing countries in Asia and Latin America is increasingly important (Figure 2–4). Thus, there is a concern that mandates to restrict greenhouse gas emissions in the United States could result in higher energy and other production costs, particularly relative to those of U.S. trading partners in the developing world without similar mandates. Higher costs could cause some U.S. industries to lose market share or to relocate production to those countries. Conversely, trade enables the United States to expand production for export in those high-productivity sectors in which the nation has comparative advantage.

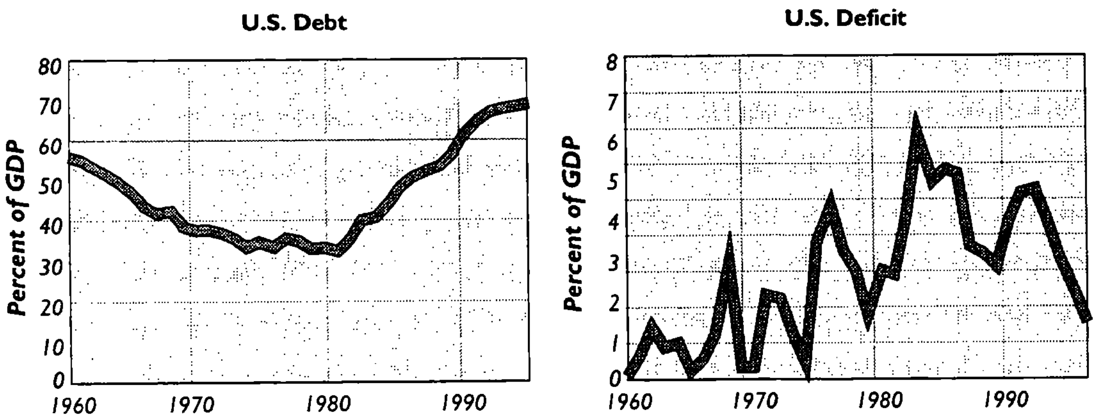
The U.S. Federal Budget

The projections for ever-tighter federal budgets in the foreseeable future are directly related to deepening public concern over budget deficits. The federal budget has been in deficit for thirty-five of the past thirty-seven years, with the peak deficit in 1992 of $290 billion. Before 1975, these deficits were not too worrisome, as the ratios of the deficit to GDP and of the debt to GDP—two measures of the relative size of the debt problem—were acceptably low. Until 1975, in fact, the ratio of deficit to GDP was stable or falling, but from 1975 through 1992 this ratio began an upward trend, which fluctuated with the business cycle (Figure 2–5). Until the 1980s the ratio of public debt to GDP also was stable or falling, but it increased dramatically from 1980 to 1992. The growing

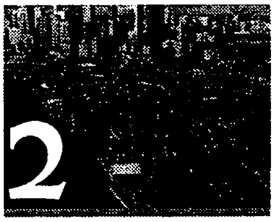
Figure 2-5

The U.S. Budget: 1960–1996

Pressure to reduce the U.S. government debt and budget deficit results in climate change actions facing ever greater competition for financial resources.



Source: EOP/CEA 1997



federal deficit, coupled with low savings rates, became unsustainable.

The resulting political consensus on the need to move toward a balanced budget has made it difficult to fund new or expanded programs. New programs related to climate change compete directly for funds with a host of existing and other new programs.

National Revenue Structure

Federal, state, and local governments in the United States collect most of their general revenue from taxes on income, sales, and property.

Federal Revenue

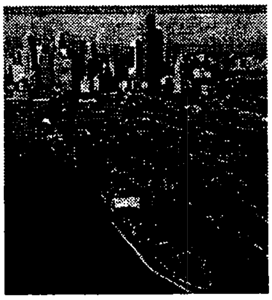
The major sources of federal government operating revenue are individual and corporate income taxes. The U.S. government levies no property or general sales tax, but does derive about 4 percent of its revenues from selected excise taxes on such items as motor fuel and alcoholic beverages. Federal motor fuel excise taxes are 18.3 cents per gallon for gasoline (or about 10–20 percent of the total price) and 24.3 cents on diesel. Of these taxes, 4.3 cents are applied toward deficit reduction, and the remaining revenues are earmarked for the Federal Highway Trust Fund. The government also earns some revenues from environmental and natural resource management, but revenue raising is not the primary purpose of these activities.

State Revenue

Sales taxes are the largest single source of state revenue. A number of states also administer income taxes, but their aggregate collections are much smaller than federal income tax revenue. All fifty states receive revenue from sales or gross receipts taxes, and only five do not impose a general sales tax. State excise taxes on motor fuel vary widely from state to state. In many cases, the state motor fuel taxes are more significant than the federal taxes. In general, more densely populated states, where driving distances are shorter, tend to impose higher gasoline taxes. In sparsely populated states higher gasoline taxes would create a major hardship for many households that must travel long distances to work, school, or shopping. State governments also rely on federal money for about a quarter of their total revenues.

Local Revenue

Property taxes are by far the major source of local revenue. In addition, some cities levy general sales and local income taxes. Local jurisdictions, especially cities, rely on federal and state sources for over a third of their budgets. Thus, the trend toward budget cutbacks at the federal and state levels is likely to exacerbate cities' budget problems and result in population outflow.



U.S. Energy Production and Consumption

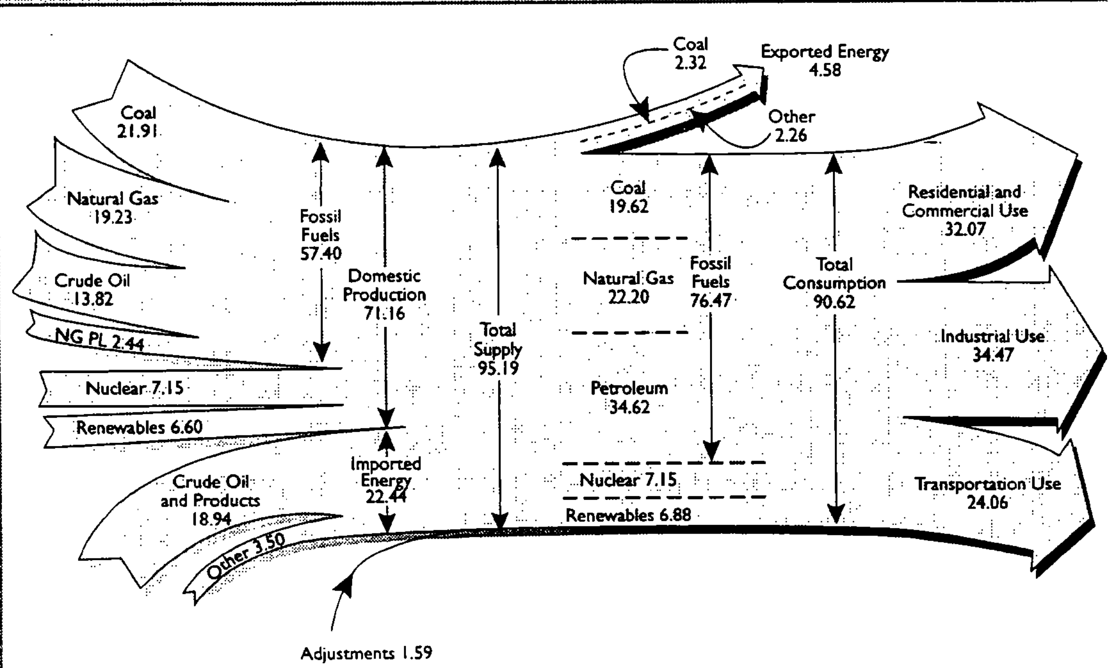
The United States is the world's largest energy producer and consumer. The nation's patterns of energy use are determined largely by its economic growth, large land area, climate regimes, low population density, and significant indigenous resources. Much of the infrastructure of U.S. cities, highways, and industries was developed in response to abundant and relatively inexpensive energy resources. Figure 2–6 provides a comprehensive overview of the energy flows through the U.S. economy in 1995.

Different regions of the country rely on different mixes of energy resources (reflecting their differing resource endowments) to generate power and meet other energy needs.

Figure 2-6

1995 Energy Flows Through the U.S. Economy
Quadrillion Btus

The U.S. energy system is complex—with imports, exports, multiple energy sources and end uses. U.S. climate policies must be tailored to this system, requiring careful attention to often competing energy needs.



Source: U.S. DOE/EIA 1996a

For example, the Pacific Northwest and Tennessee Valley have abundant hydropower resources, while the Midwest relies heavily on coal for power generation and industry.

Resources

The vast fossil fuel resources of the United States have contributed to low prices and specialization in relatively energy-intensive activities. Coal, which has the highest emissions of greenhouse gases per unit of energy, is particularly abundant, with current recoverable reserves estimated at about 272 billion short tons—enough to last for over 250 years at current recovery rates. Recent gains in mining productivity, coupled with increased use of less-expensive western coal made possible by railroad deregulation and removal of some Clean Air Act restrictions that discouraged the use of western coal, have led to a continual decline in coal prices over the past sixteen years. The low cost of coal on a Btu basis has made it the preferred fuel for power generation, supplying over half of the energy consumed to generate electricity.

Proved reserves of oil have been on a downward trend ever since the addition of reserves under Alaska's North Slope in 1970. Restrictions on exploration in many promising but ecologically sensitive areas have constrained additions to reserves. Reserves of natural gas are about 172 trillion cubic feet, which will last over 65 years at current rates of production. U.S. energy resources also include some 265 million pounds (120 million kg) of

The U.S. Energy Policy Act

Several titles of the U.S. Energy Policy Act are extremely important to the overall U.S. strategy of reducing greenhouse gas emissions.

Title I—The energy efficiency title establishes energy efficiency standards, promotes utility energy management programs and dissemination of energy-saving information, and provides incentives to state and local authorities to promote energy efficiency.

Titles III, IV, V, and VI—The alternative fuels and vehicle titles provide monetary incentives, establish federal requirements, and support the research, design, and development of fuels and vehicles that can reduce oil use and, in some cases, carbon emissions as well.

Titles XII, XIX, XXI, and XXII—The renewable-energy title, the revenue provisions, the energy and environment title, and the energy and economic growth title promote increased research, development, production, and use of renewable-energy sources and more energy-efficient technologies.

Title XVI—The global climate change title provides for the collection, analysis, and reporting of information pertaining to global climate change, including a voluntary reporting program to recognize utility and industry efforts to reduce greenhouse gas emissions.

Title XXIV—This title facilitates efforts to increase the efficiency and electric power production of existing federal and nonfederal hydroelectric facilities.

Title XXVIII—This title streamlines licensing for nuclear plants.

uranium oxide, recoverable at $30 per pound or less. Hydroelectric resources are abundant in certain areas of the country, where they have largely already been exploited.

Production

Coal, natural gas, and crude oil contribute the bulk of U.S. energy production. In 1960 these fossil fuels accounted for approximately 95 percent of production, but by 1995 their contribution had fallen to about 81 percent, with the nuclear electric power displacing some of the fossil fuel production (Figure 2–7). Further displacement will likely be limited, however, due to uncertainties related to deregulation of the electric industry, difficulty in siting new nuclear facilities, and management of commercial spent fuel. Renewable resources contribute a small but growing share.

Before 1970, the United States imported only a small amount of energy, primarily in the form of petroleum. Beginning in the early 1970s, however, lower acquisition costs for imported crude oil and rising costs of domestic production put domestic U.S. oil producers at a comparative disadvantage, leading to a divergence in trends of energy production and consumption.

Domestic oil production is projected to continue to decline, due to depletion of existing reserves with few new discoveries. However, it is likely to stabilize and even increase slightly after 2006, in response to rising prices and technological gains. Oil consumption will likely continue to rise, by a projected 0.9 percent a year, easily outstripping production. As a result, U.S. net oil imports of about 8 million barrels per day, which accounted for 45 percent of consumption in 1994, will continue to rise, but are projected to stabilize at about 57 percent of consumption in 2010.

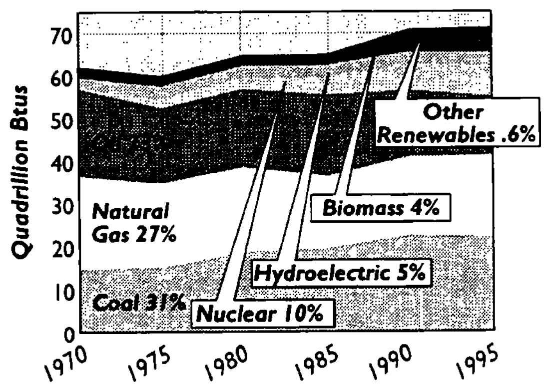
Coal is the largest source of domestically produced energy. As the only fossil fuel for which domestic production exceeds consumption, coal assumed a particularly important role in the wake of the oil shocks in the 1970s. The United States exported 88.5 million short tons of coal (or 8.6 percent of production in 1995) mostly to Japan, Canada, and Italy. Projected increases in demand for electric power production and for export are expected to stimulate further coal production, increasing coal's share of total U.S. primary energy production from 29 percent in 1993 to 32 percent in 2015.

Regulatory and legislative changes in the mid-1980s led to proper market pricing of

Figure 2-7

U.S. Energy Production: 1970–1995

Coal is the largest source of domestic energy. The production of coal, nuclear, and, more recently, renewables has risen to offset the decline in oil and natural gas production initiated in 1970.



Note: Percents add to more than 100.
Source: U.S. DOE/EIA 1996a

natural gas. These changes heightened demand and boosted natural gas production, reversing the decline it had experienced in the 1970s and early 1980s. This increased production is projected to continue and even accelerate in the early decades of the twenty-first century. Nonetheless, growth in consumption is expected to outstrip that of production, leading to an increase in net imports, from the 1995 level of 2.56 trillion cubic feet (or 12 percent of consumption) to a projected level of 4.02 trillion cubic feet (14 percent of consumption) in 2015.

Renewable sources currently constitute 9.3 percent of the national energy supply. Hydropower, which currently contributes 4.5 percent, is not expected to expand, but the share of biomass, currently at 4.1 percent, is already growing rapidly. Solar, wind, and geothermal energy, which currently contribute a scant 0.64 percent to domestic energy supply, are expected to grow steadily at rates exceeding those of other sources between now and 2010.

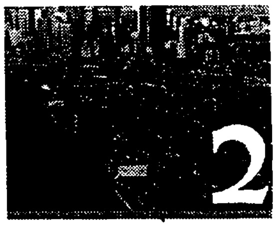
Electricity Market Restructuring

The U.S. electric industry is evolving toward competition in both wholesale and retail markets. The transition involves changes of a fundamental nature that will transform virtually every part of the industry. Today's vertically integrated (i.e., generation/transmission/distribution) utilities, selling at retail in geographically bounded franchise areas, will be replaced by companies operating under different formats. The generation sector will be largely freed of price regulation, while the transmission sector will remain subject to federal price regulation as a natural monopoly. In areas where state regulators authorize retail competition, a competing firm will offer retail customers a variety of service packages and will pay a "rental fee" to the local distribution utility for the use of its wires network to deliver the product to the customer.

Important new categories of corporate players are emerging, such as marketers, brokers, futures traders, and energy service companies. All companies in the market will need to develop innovative packages of services to win and retain wholesale and retail customers. Regulation, too, will change: it will be focused more narrowly on transmission and distribution functions, but it will not be eliminated. The emerging electricity markets, both wholesale and retail, will be regional in scope. Creating appropriate mechanisms for regulation of a regional-scale industry will challenge federal, state, and industry decision makers.

Some of these mechanisms are already emerging. In 1996, for example, the Federal Energy Regulatory Commission issued its Orders 888 and 889, which establish a regime for nondiscriminatory access by all wholesale buyers and sellers to transmission facilities. The Commission is currently reviewing several proposals to establish regional "independent system operators"—entities that would have the responsibility to provide reliable, nondiscriminatory, and economically efficient transmission services on a regional basis.

Similarly, fundamental changes in the structure and operations of the industry will require complementary changes in the federal and state legal frameworks for the industry's governance. Some states (e.g., California and Pennsylvania) have already enacted legislation to guide the transition to retail competition, and many others are considering such legislation. However, important legisla-



tive changes are also needed at the federal level, and the U.S. Department of Energy is working with other federal departments and a wide array of other organizations and groups to develop an Administration proposal for federal electric legislation.

Currently, coal-fired power plants contribute the bulk of U.S. electricity, at 56 percent, followed by nuclear at 22 percent, natural gas at 11 percent, and conventional hydropower at 10 percent. Over the past few years, and in near-term projections, natural gas has been the fuel of choice for new electricity-generating capacity. The restructuring of the electric power industry is likely to accelerate this trend, due to the fact that natural gas generation is less capital-intensive than other technologies, and the cost of capital to the electric power industry is expected to increase.

Consumption

On the consumption side, rapid economic growth, combined with the increasing energy demands of the transportation and buildings sectors, resulted in an 80 percent increase in energy demand from 1960 to 1979 (Figure 2–8). Most of the increased demand was met by oil imports and by increased consumption of coal and natural gas. Demand dampened during and after the international oil price shocks in 1973–74 and 1979–80, and overall energy consumption actually fell through the early 1980s. Energy consumption resumed its upward trend in the latter half of the 1980s, in response to declining oil prices and renewed economic growth. Another lingering effect of the oil price shocks was a shift in consumption away from oil toward natural gas, coal, and nuclear power for power generation, and natural gas and electricity for space heating.

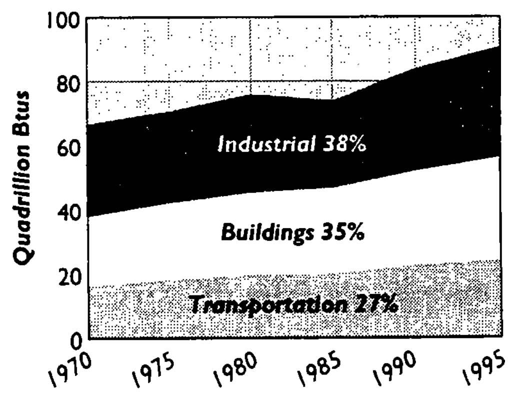
Growth in the economy, population, and distances traveled could have propelled U.S. energy consumption far beyond its nearly 100 percent growth since 1960, had there not been impressive reductions in the energy intensity of the U.S. economy. There has been a 31.5 percent decrease in energy use per dollar of GDP from its 1970 peak, with intensity basically flat after 1986. Most of these intensity improvements have come from the industrial sector, although the household and transportation sectors also experienced significant gains. U.S. energy use per GDP is just slightly above the OECD average (at 0.43 kg of oil equivalent per dollar of GDP, versus 0.41 kg for the OECD).

In 1993, end users consumed 63.2 quadrillion Btus (quads) of energy, including

Figure 2-8

U.S. Primary Energy Consumption: 1970–1995

Energy consumption is divided relatively evenly among the industrial, buildings, and transportation sectors. The industrial sector is still the largest, but the buildings and transportation sectors are the fastest growing.



Source: U.S. DOE/EIA 1996a

9.75 quads of electricity, directly. An additional 20.54 quads of energy were used in the generation, transmission, and distribution of electricity. Industry and transportation consumed nearly three-quarters of this direct energy, while the residential and commercial sectors used 27 percent. However, because most electricity is delivered to residential and commercial users, total primary energy consumption of 83.8 quads is distributed fairly evenly among final users.

Industrial Energy Use

The industrial sector—comprised of manufacturing, construction, agriculture, and mining—accounted for 38 percent of total U.S. energy use in 1995 and approximately 40 percent of total U.S. greenhouse gas emissions. Industry's energy consumption rose steadily until the early 1970s, then dropped markedly, particularly in the early 1980s, following the second oil shock. Since the late 1980s, industrial energy consumption has resumed a gradual upward trend.

Similarly, from 1972 to 1990, industrial energy intensity (energy used divided by industrial contribution to GDP) fell by 35.3 percent. Approximately two-thirds of this decline was due to structural shifts, such as the changing array of products that industry produced. The remaining one-third is attributable to efficiency improvements.

Energy intensity in the manufacturing sector has declined over the past two decades, although the rate of decline has slowed since energy prices fell in 1985. Of the fifteen major energy-consuming industry groups in the manufacturing sector, most continued to reduce their energy intensity between 1980 and 1991.

Residential and Commercial Energy Use

The number, size, and climatic distribution of residential and commercial buildings, as well as the market penetration of heating and cooling technologies and major appliances, all combine to influence the energy consumption and greenhouse gas emissions associated with residential and commercial activities.

The United States has about 99 million households, approximately half of which live in detached, single-family dwellings. Demographic changes have led to a steep decline in the average number of people per residence—3.33 in 1960 to 2.63 in 1990. The average heated space per person had increased to 55.9 square meters (602 square feet) in 1990, compared to 49.6 square meters (534 square feet) in 1980.

In addition, major energy-consuming appliances and equipment came into widespread use during this period. By 1990, essentially all U.S. households had space heating, water heating, refrigeration, cooking, and color television sets. About 68 percent had some form of air conditioning, 77 percent had clothes washers, roughly 71 percent had clothes dryers, and 45 percent had dishwashers (Figure 2–9).

On the other hand, large gains in the energy efficiency of appliances and building shells (e.g., through better insulation) have more than offset the growth in appliance penetration and heating/cooling space per person, resulting in a modest decline in residential energy use per person and only modest increases in total U.S. energy demand in the residential sector. Increased use of nontraditional electrical appliances, such as computers and cordless (rechargeable) tools, is expected to drive a gradual (0.8 percent per year) rise in both overall and per-household residential energy consumption between 1990 and 2015.

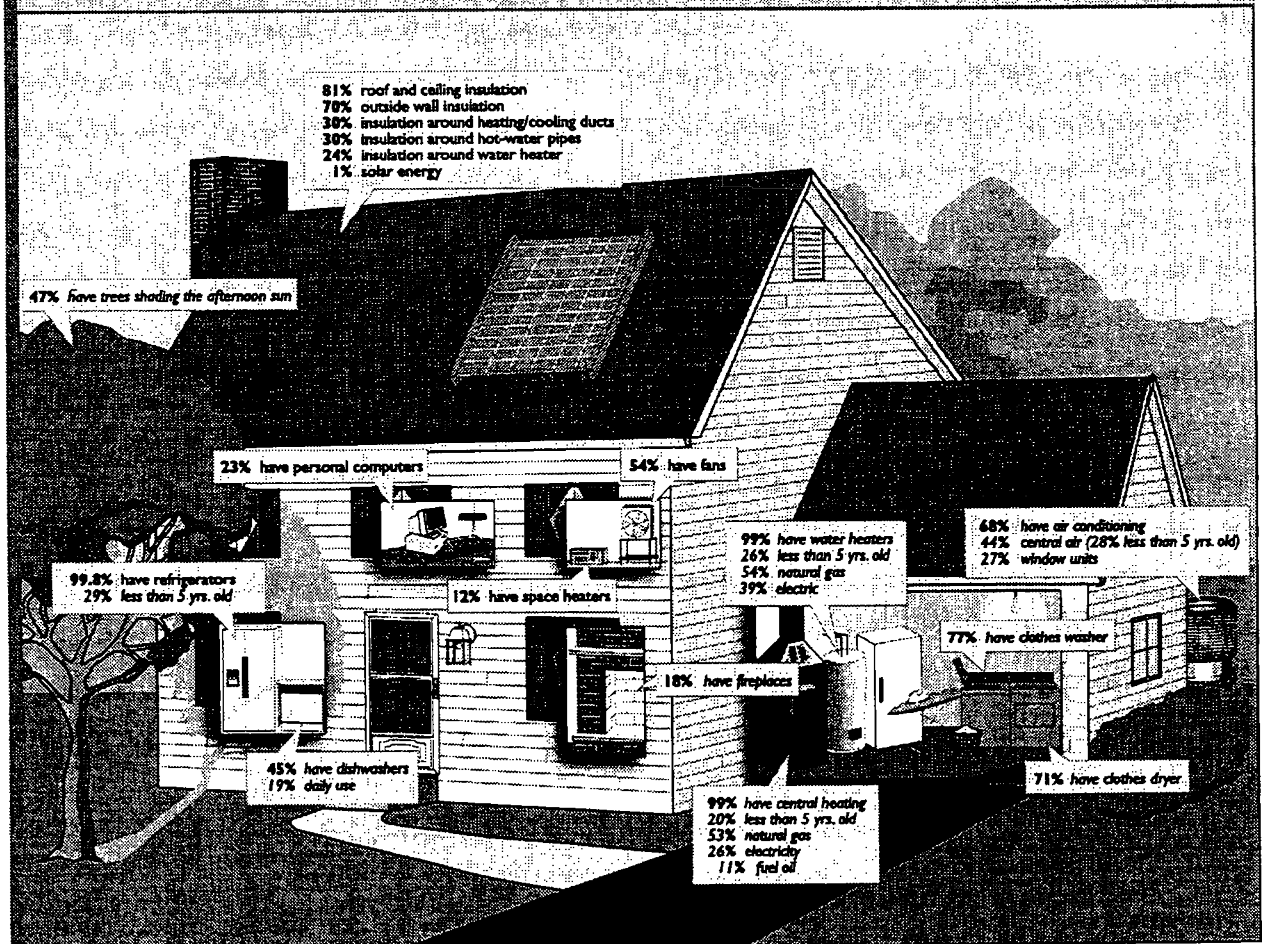
Commercial buildings house the rapidly growing financial and services sectors. Accordingly, the number of commercial buildings and their total square footage have increased steadily. Virtually all commercial buildings are heated, and more than 80 percent are cooled. In addition, the past decade has seen a major increase in the use of computers and other energy-consuming office equipment.

Rapid growth in the financial and services sectors has substantially increased the energy services required by commercial buildings. However, as in the residential sector, substantial efficiency gains have reduced the net increases in energy demand and carbon emis-

Figure 2-9

Energy Characteristics of U.S. Households

U.S. households have a variety of energy-consuming and -conserving features. The graphic below depicts the percentages of all U.S. households that have some of these features.



Source: U.S. DOE/EIA 1993b

sions. The widespread introduction of efficient lighting and ENERGY STAR® and other more efficient office equipment should help to continue this trend. The entry into the market of energy service companies, which contract with firms or government agencies to improve building energy efficiency and are paid out of the stream of energy savings, has aided the trend toward greater energy efficiency in the commercial buildings sector.

Residential and commercial buildings together account for roughly 35 percent of the U.S. carbon emissions associated with energy consumption. Commercial buildings—which encompass all nonresidential, privately owned, and public buildings—account for about 16 percent. Total energy use in the buildings sector is roughly stable, with efficiency gains offsetting increases in capacity and needed energy services.

Transportation Energy Use

The U.S. transportation sector has evolved into a multimodal system, including waterborne, highway, mass transit, air, rail, and pipeline transport (Figure 2–10). Automobiles and light trucks dominate the passenger transportation system. In 1990, the highway share of passenger travel was 85 percent, while air travel accounted for 11 percent. In contrast, bus and rail travel's combined share was only 4 percent.

Overall, the transportation sector consumed 23.96 quadrillion Btus in 1995, accounting for approximately one-third of U.S. greenhouse gas emissions.

Because of the dominance of motor vehicles in the U.S. transportation system, motor vehicle ownership rates, use, and efficiency drive energy consumption and greenhouse gas emissions in the transportation sector. Between 1960 and 1995, the number of cars and trucks registered in the United States more than doubled, from 74 million to 200 million. Rising incomes, population growth, and settlement patterns have been the primary factors in this trend.

Both the number of vehicles on the road and the average distance they are driven have increased. In 1993, passenger cars were driven 18,814 kilometers (11,759 miles) per year on average, compared to only 16,435 kilometers (10,272 miles) in 1970. The distance traveled per car has increased steadily over the last two decades, interrupted only by the oil shocks in 1974 and 1979. The total vehicle kilometers traveled in the United States have increased by over 50 percent since 1970.

These increases have been significantly offset by enhanced efficiency. A combination of factors, including the implementation of Corporate Average Fuel Economy (CAFE) standards for new cars, improved average fuel consumption per kilometer, from a low of 18 liters per 100 kilometers (13 miles per gallon) for passenger cars in 1973 to 11 liters per 100 kilometers (21.5 miles per gallon) in 1994. The fuel economy of light trucks has also improved, although the increased share of light trucks in the total light-duty-vehicle fleet has diminished these overall gains. Thus, as in other sectors, efficiency moderated the increase in motor fuel consumption in the transportation sector to 26 percent, from 7,460,000 barrels per day in 1973 to 9,374,000 barrels per day in 1995.

The causes for the rapid rise in vehicle miles traveled are numerous, although their relative importance is unclear. In 1990, there

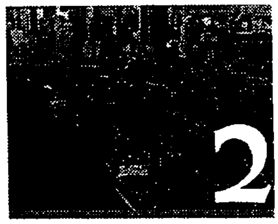


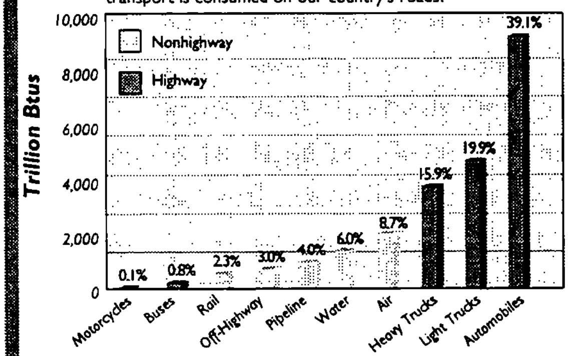
Figure 2-10

U.S. Transportation: Characteristics and Trends

The U.S. transport system is heavily biased toward private vehicle use. In spite of increasing automobile efficiency, overall energy consumption, driven by stable fuel prices, has risen substantially over the past two decades. Air travel, which accounts for more than 10 percent of all passenger miles traveled, has also experienced impressive growth. The significant reductions in the energy intensity of all freight modes have not offset these increases in consumption.

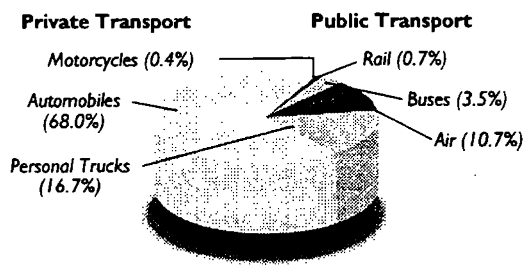
Energy Use by Transportation Mode: 1994

Nearly three-quarters of the 22,886 trillion Btus used in transport is consumed on our country's roads.



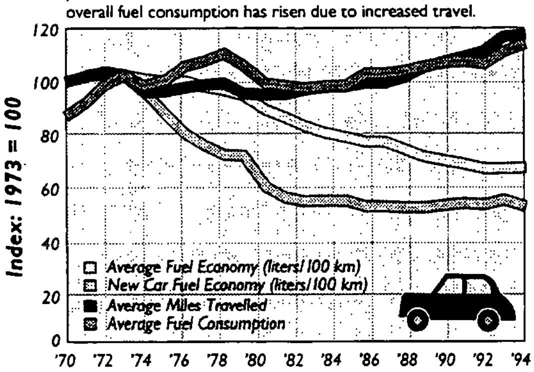
Passenger Miles Traveled

Of the 3,729,622 miles traveled in 1994, private vehicles accounted for approximately 85 percent.



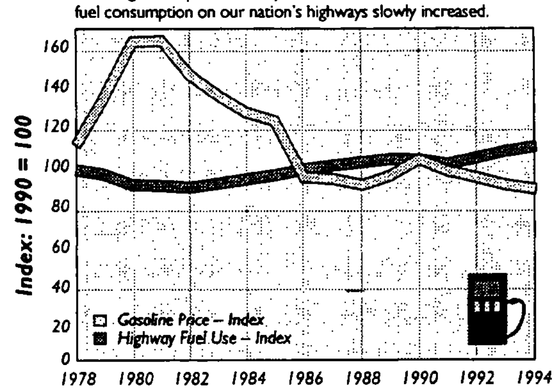
Passenger Car Use

While CAFE standards and other factors have led to a 34 percent decrease in the amount of fuel consumed per kilometer, overall fuel consumption has risen due to increased travel.



Gasoline Prices and Fuel Use

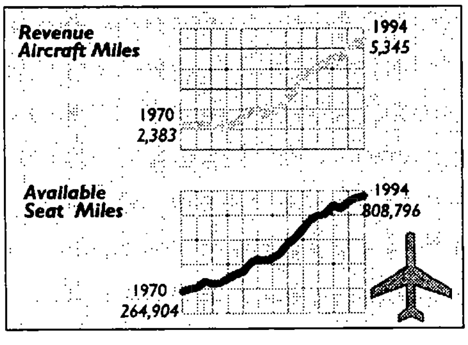
As real gasoline prices steadily decreased between 1990 and 1994, fuel consumption on our nation's highways slowly increased.



Air Transport

(Millions of miles)

Between 1970 and 1994, revenue aircraft miles more than doubled (growing at 3.4 percent annually), while available seat miles grew threefold (with annual average rates of 4.8 percent).



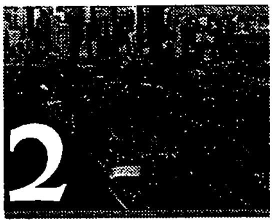
Energy Intensity of Freight Modes

The energy intensity of U.S. freight transportation is decreasing steadily. Domestic waterborne commerce and truck transport were 32 percent less intensive in 1994 than in 1970, while railroads consumed 44 percent less energy.

	All Trucks (Thousands of Btus per Vehicle Mile)	Class I Freight Railroad* (Btus per Ton Mile)	Domestic Waterborne Commerce (Btus per Ton Mile)
1970	16,404	691	545
1975	14,282	687	549
1980	13,459	597	358
1985	13,117	497	446
1990	12,171	420	388
1994	11,158	388	369

* *These data have changed from previous editions due to a change in source for energy-use data. Previous estimates were based on sales.*

Sources: U.S. DOT/FAA 1995, U.S. DOT/RSPA 1982–94, U.S. DOT/CAB 1970–81



Intermodal Surface Transportation Efficiency Act of 1991

"ISTEA" provides for improved operation of the transportation system and gives state and local government increased flexibility in spending federal funds for a variety of projects that would help reduce greenhouse gas emissions. For example:

- State and local transportation officials may redirect federal highway construction funds toward the development of high-occupancy-vehicle (carpool) lanes and transit facilities.
- ISTEA provides for testing and implementing intelligent-vehicle and highway-system technologies and services to reduce congestion, energy use, and emissions.
- The Act created the Congestion Management and Air Quality Improvement Program to allow state and local officials to redirect transportation funds to help certain areas meet the standards set by the Clean Air Act Amendments of 1990.

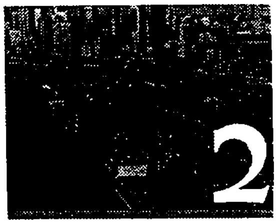
The Administration and Congress have begun efforts to reauthorize and extend this legislation during 1997.

were more personal vehicles than licensed drivers (1.02 vehicles per licensed driver), compared to 0.88 vehicles per licensed driver in 1970. This rise in ownership rates translates into increased vehicle use by reducing people's need to carpool or use public transportation, but it may indicate a saturation effect that will slow further growth in vehicle use. Greater vehicle ownership and use are related to a host of factors, including changing patterns of land use, such as location of work and shopping centers; the changing composition of the work force, such as the growing number of women in the work force; and reduced costs of driving.

Over 3.1 trillion ton-miles of freight are moved in the United States each year. The predominant mode of intercity freight is rail, followed by waterways, highways, pipelines, and air.

- Between 1970 and 1990, the number of railroad cars in use declined. However, they carried more freight for greater distances, resulting in a 0.5 percent reduction in overall energy use for rail freight since 1970, and a 2.4 percent improvement in energy intensity.
- Heavy trucks account for most of the freight sector's energy use. From 1970 to 1994 their energy consumption more than doubled, though their fuel efficiency increased slightly.
- Ton-miles shipped by air increased rapidly—by 6.3 percent per year from 1970 to 1994—but total aviation energy use grew by only 2.1 percent per year.
- Water-transport and oil-pipeline shipments grew steadily over that same period.

Stagnant energy intensity in overall freight transport suggests that improvements in energy use per ton mile within individual modes of freight transport have been offset by a gradual shift in traffic to more energy-intensive modes.



Government Energy Use

The U.S. government is the nation's single largest energy user. In 1995, the federal government consumed approximately 1.66 quadrillion Btus (or about 1.9 percent) of the total 87.30 quads of primary energy consumed in the United States. The energy was used in government buildings and operations widely dispersed across the entire nation and every climate zone, to provide essential services to U.S. citizens.

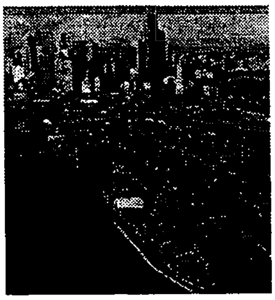
Based on reports submitted to the Department of Energy by twenty-eight federal agencies, the U.S. government consumed 1.15 quads during fiscal year 1995, when measured in terms of energy actually delivered to the point of use. This total net energy consumption represented a 20.5 percent decrease from the 1985 base year, and a 20 percent decrease from 1990. Based on these figures, the federal government was responsible for about 28.6 million metric tons of carbon emissions in 1995—a reduction of about 5.2 million metric tons, or 18 percent, from 1990.

The Department of Defense dominates the federal government's energy consumption, accounting for just over 80 percent of total energy use and 93 percent of vehicle and equipment energy use. Overall in 1995, energy consumption by vehicles and equipment accounted for 59 percent of the total, buildings for 32 percent, and energy-intensive operations for 9 percent. Energy use by fuel type was as follows: jet fuel, 45 percent; electricity, 18 percent; natural gas, 13 percent; diesel, 7 percent; fuel oil, 5 percent; and other fuels, 8 percent.

Energy Savings in Federal Agencies

Federal agencies—initially in response to the energy crises of the 1970s, and later because it just made good business sense—have been steadily pursuing energy and cost savings in their buildings and operations. Under the Federal Energy Management Program, federal agencies have invested several billion dollars in energy efficiency over the past twenty years and have substantially reduced consumption. In federal buildings, the primary focus of the program, 1995 energy consumption was down 22.7 percent from 1985 levels, and energy use per gross square foot of floor space was down 14.7 percent.

The Energy Policy Act of 1992 and Executive Order 12902 further challenge federal energy managers to reduce consumption by 20 percent per square foot by the year 2000, and by 30 percent by 2005, relative to a 1985 baseline. With declining federal resources available, the Federal Energy Management Program is emphasizing the use of private-sector investment through energy-saving performance contracting and utility financing of energy efficiency to meet these goals. The combination of federal funding and the anticipated private-sector funding of up to $4.3 billion through 2005 should make these goals attainable. In addition, agencies are making cost-effective investments in renewable-energy and water-conservation projects, and further savings are being pursued through an energy-efficient procurement initiative.



U.S. Governing Institutions

The political and institutional systems participating in the development and protection of environmental and natural resources in the United States are as varied as the resources themselves. These systems span federal, state, and local government jurisdictions, and include legislative, regulatory, judicial, and executive institutions.

The U.S. government is divided into three separate branches: the executive branch, which includes the Executive Office of the President, departments, and independent agencies; the legislative branch (the U.S. Congress); and the judicial branch (the U.S. court system). There is a distinct separation of powers in this tripartite system—quite different from parliamentary governments. Even when the President and Congress are from the same political party, the executive and legislative branches may have very different views on issues; these differences are compounded when they represent different parties. Within the U.S. Congress, regional concerns and the need to represent the economic needs of the home district often outweigh party loyalty.

Federal Departments and Agencies

The executive branch is comprised of fourteen executive departments, seven agencies, and a host of commissions, boards, other independent establishments, and government corporations. The traditional functions of a department or agency are to help the President propose legislation; to enact, administer, and enforce regulations and rules implementing legislation; to implement Executive Orders; and to perform other activities in support of the institution's mission, such as encouraging and funding research, development, and demonstration of new technologies.

No single department, agency, or level of government in the United States has sole responsibility for the panoply of issues associated with climate change. In many cases, the responsibilities of federal agencies are established by law, with limited administrative discretion. At the federal level, U.S. climate change policy is determined by an interagency coordinating committee, chaired from within the Executive Office of the President, and staffed with members of the executive offices and officials from the relevant departments and agencies, including the Departments of Agriculture, Commerce, Energy, Justice, State, Transportation, and Treasury, as well as the Environmental Protection Agency.

The U.S. Congress

As the legislative branch of the U.S. government, Congress also exercises responsibil-

ity for climate change and other environmental and natural resource issues at the national level. It influences environmental policy through two principal vehicles: the creation of laws and the oversight of the federal executive branch. Thus, Congress can enact laws establishing regulatory regimes for environmental purposes, and can pass bills to appropriate funds for environmental purposes. Under its constitutional authority, the Senate ratifies international treaties, such as the U.N. Framework Convention on Climate Change.

The U.S. Congress comprises two elected chambers—the Senate and the House of Representatives—having generally equal functions in lawmaking. The Senate has 100 members, elected to six-year terms, with two representatives for each state. The House has 435 members, elected to two-year terms, each of whom represents a district in a state. The less populated but often resource-rich regions of the country, therefore, have proportionately greater influence in the Senate than in the House.

Environmental proposals, like most other laws, may be initiated in either chamber. After their introduction, proposals—or "bills"—are referred to specialized committees and subcommittees, which hold public hearings on the bills to receive testimony from interested and expert parties. After reviewing the testimony, they deliberate and revise the bills, and then submit them for debate by the full membership of that chamber. Differences between bills originating in either the House or the Senate are resolved in a formal conference between the two chambers. To become a law, a bill must be approved by the majorities of both chambers, and then must be signed by the President. The President may oppose and veto a bill, but Congress may override a veto with a two-thirds majority from each chamber.

Spending bills must go through this process twice. First, the Committee with responsibility for the relevant issue must submit a bill to authorize the expenditure. Then, once both chambers pass the authorization bill, the Appropriations Committee, in a completely separate process, must submit a bill appropriating funds from the budget. Thus, the funds that are actually appropriated are often substantially less than the authorized amount.

State and Local Governments

States, localities, and even regional associations still exert significant influence over the passage, initiation, and administration of environmental, energy, natural resource, and other climate-related programs. For example, the authority to regulate electricity production and distribution lies with state and local public utility commissions. In addition, the regulation of building codes—strongly tied to the energy efficiency of buildings—is also controlled at the state and local levels.

Each of the fifty states enjoys significant autonomy in its approach to environmental regulation and management activities. States implement some federal laws by issuing permits and monitoring compliance with regulatory standards. States also generally have the discretion to set standards more stringent than the national standards. In addition to regulation, some states and localities have developed programs that encourage energy efficiency and conservation or that otherwise mitigate projected levels of greenhouse gas emissions.

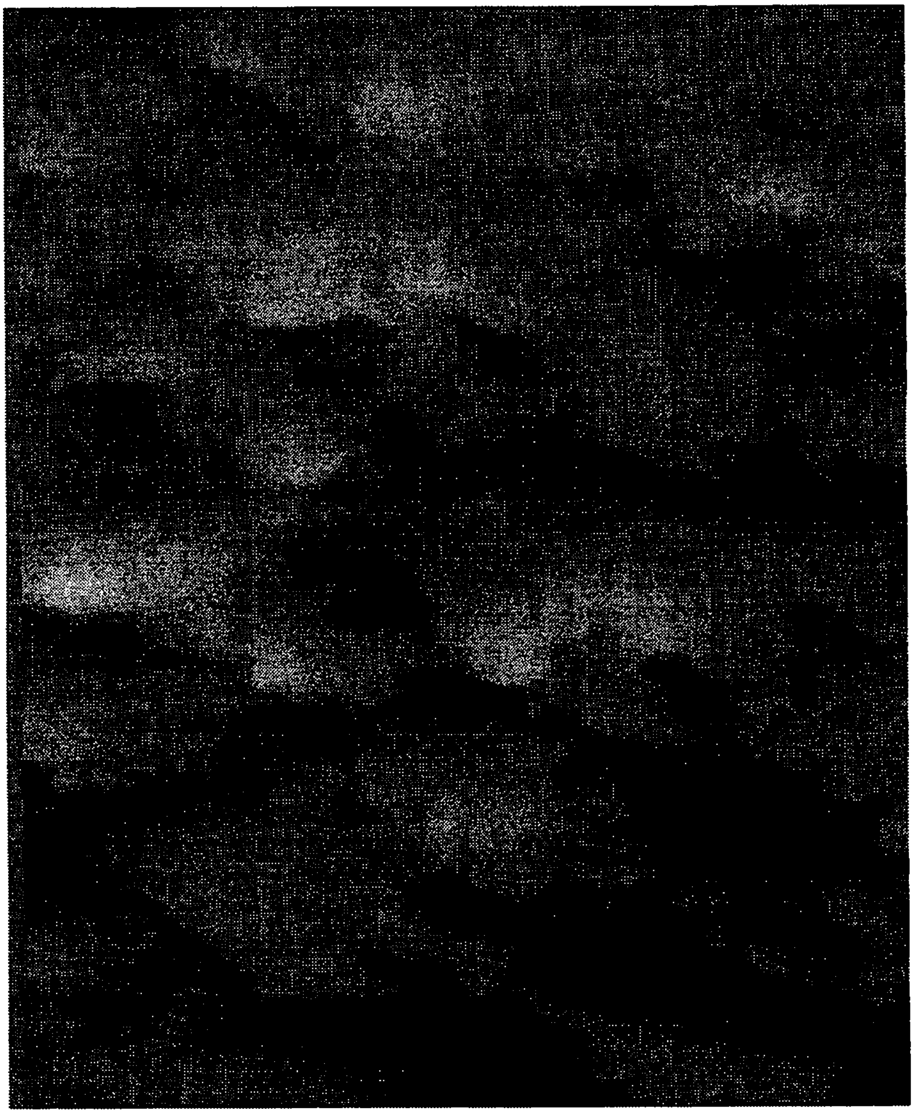
Local power to regulate land use is derived from a state's power to enact legislation to promote the health, safety, and welfare of its citizens. States vary in the degree to which they delegate these "powers" to local governments, but land use usually is controlled to a considerable extent by local governments (county or city). This control may take the form of authority to adopt comprehensive land-use plans; to enact zoning ordinances and subdivision regulations; or to restrict shoreline, floodplain, or wetland development.

The U.S. Court System

The U.S. court system is also crucial to the disposition of environmental issues. Many environmental cases are litigated in the federal courts. The federal court system is three-tiered: the district court level; the first appellate, or circuit, court level; and the second and final appellate level, the U.S. Supreme Court. There are ninety-four federal district courts, organized into federal circuits, and thirteen federal appeals courts.

Cases usually enter the federal court system at the district court level, though some challenges to agency actions are heard directly in appellate court, and disputes between states may be brought directly before the Supreme Court. Generally, any person (regardless of citizenship) may file a complaint alleging a grievance. In civil enforcement cases, complaints are brought on behalf of the government by the U.S. attorney general and, in some instances, may be filed by citizens as well.

Sanctions and relief in civil environmental cases may include monetary penalties, awards of damages, and injunctive and declaratory relief. Courts may direct, for example, that pollution cease, that contaminated sites be cleaned up, or that environmental impacts be assessed before a project proceeds. Criminal cases under federal environmental laws may be brought only by the government—the attorney general or state attorneys general. Criminal sanctions in environmental cases may include fines and imprisonment.

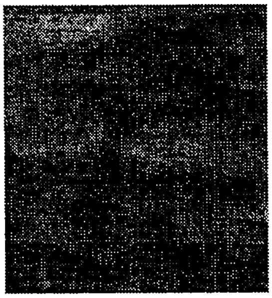


Central to any study of climate change is the development of an emission inventory that identifies and quantifies a country's primary sources and sinks of greenhouse gases. This inventory provides both (1) a basis for the ongoing development of a comprehensive and detailed methodology for estimating sources and sinks of greenhouse gases and (2) a common, consistent mechanism that enables all signatory countries to the United Nations' Framework Convention on Climate Change (FCCC) to estimate emissions and to compare the relative contributions of different emission sources and greenhouse gases to climate change. Moreover, systematically and consistently estimating national and international emissions is a prerequisite for evaluating the cost-effectiveness and feasibility of mitigation strategies and emission reduction technologies.

This chapter summarizes the latest information on U.S. greenhouse gas emission trends from 1990 to 1995, as presented in the draft EPA report *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–1995*. To ensure that the U.S. emissions inventory is comparable to those of other FCCC signatory countries, the estimates presented here were calculated using baseline methods similar to those recommended in Volumes 1–3 of the *IPCC Guidelines for National Greenhouse Gas Inventories* (IPCC/OECD/IEA/UNEP 1995). For U.S.

greenhouse gas inventory

emission sources related to energy consumption, forest sinks, and some CH_4 sources, the IPCC default methodologies were expanded, resulting in a more comprehensive procedure for estimating U.S. emissions. Details on how these estimates were developed are available in the 1995 *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1994* (U.S. EPA 1995) and in the upcoming edition.



Recent Trends in U.S. Greenhouse Gas Emissions

Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and ozone (O_3). Chlorofluorocarbons (CFCs), a family of human-made compounds, and other compounds, such as hydrofluorocarbons (HFCs) and perfluorinated carbons (PFCs), are also greenhouse gases.

Other nongreenhouse, radiatively important gases—such as carbon monoxide (CO), oxides of nitrogen (NO_X), and nonmethane volatile organic compounds (NMVOCs)—contribute indirectly to the greenhouse effect. These are commonly referred to as "tropospheric ozone precursors" because they influence the rate at which ozone and other gases are created and destroyed in the atmosphere. For convenience, all gases discussed in this chapter are generically referred to as "greenhouse gases" (unless otherwise noted).

Although CO_2, CH_4, and N_2O occur naturally in the atmosphere, their recent atmospheric buildup is largely the result of human activities. Since 1800, atmospheric concentrations of these greenhouse gases have increased by 30, 145, and 15 percent, respectively (IPCC 1996). This buildup has altered the composition of the Earth's atmosphere and may affect future global climate.

Beginning in the 1950s, the use of CFCs increased by nearly 10 percent a year, until the mid–1980s when international concern about ozone depletion led to the signing of the *Montreal Protocol*. Since then, the consumption of CFCs has rapidly declined as they are phased out. In contrast, use of CFC substitutes is expected to grow significantly.

Figure 3-1 and Table 3-1 summarize the current U.S. greenhouse gas emissions inventory for 1990-95. They present the estimated sources and sinks in millions of metric tons of *carbon equivalent* (MMTCE), which accounts for the gases' global warming potentials.

The growth of U.S. greenhouse gas emissions has been erratic from 1990 to 1995.

Figure 3-1

Recent Trends in U.S. Greenhouse Gas Emissions: 1990–1995

Since 1990, overall emissions of CO_2 have increased, while emissions of other greenhouse and photochemically important gases have remained relatively constant or have declined.

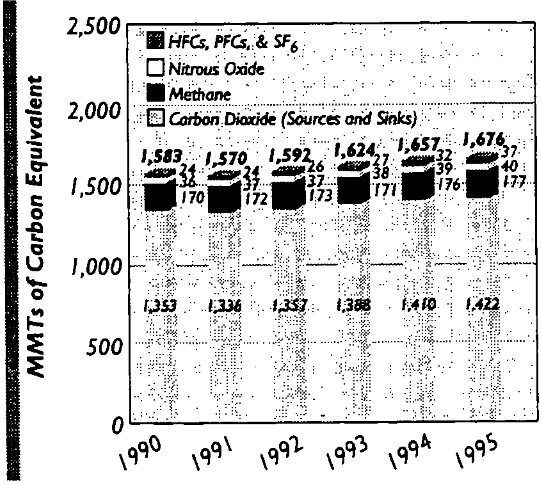


Table 3-1

Recent Trends in U.S. Greenhouse Gas Emissions: 1990–1995
(MMTs of Carbon Equivalent)

Gases and Sources	Emissions—Direct and Indirect Effects					
	1990	1991	1992	1993	1994	1995
Carbon Dioxide (CO_2)	**1,228**	**1,213**	**1,235**	**1,268**	**1,291**	**1,305**
Fossil Fuel Combustion	1,336	1,320	1,340	1,370	1,391	1,403
Industrial Processes and Other	17	16	17	18	19	19
Total	*1,353*	*1,336*	*1,357*	*1,388*	*1,410*	*1,422*
Forests (sink)*	(125)	(123)	(122)	(120)	(119)	(117)
Methane (CH_4)	**170**	**172**	**173**	**171**	**176**	**177**
Landfills	56	58	58	60	62	64
Agriculture	50	51	52	52	54	55
Coal Mining	24	23	22	20	21	20
Oil and Natural Gas Systems	33	33	34	33	33	33
Other	6	7	7	6	6	6
Nitrous Oxide (N_2O)	**36**	**37**	**37**	**38**	**39**	**40**
Agriculture	17	17	17	18	18	18
Fossil Fuel Consumption	11	11	12	12	12	12
Industrial Processes	8	8	8	8	9	9
HFCs	**12**	**12**	**13**	**14**	**17**	**21**
PFCs	**5**	**5**	**5**	**5**	**7**	**8**
SF_6	**7**	**7**	**8**	**8**	**8**	**8**
U.S. Emissions	**1,583**	**1,570**	**1,592**	**1,624**	**1,657**	**1,676**
Net U.S. Emissions	**1,458**	**1,447**	**1,470**	**1,504**	**1,538**	**1,559**

Note: The totals presented in the summary tables in this chapter may not equal the sum of the individual source categories due to rounding.

Emissions from anthropogenic sources dropped in 1991, increased steadily through 1994, and then slowed down in 1995. Over the five-year period, greenhouse gas emissions rose by 5.9 percent, representing an average annual increase of just over one percent. This trend is largely attributable to changes in total energy consumption resulting from the economic slowdown in the early 1990s and the subsequent recovery. U.S. energy consumption increased at an average annual rate of 1.5 percent over the same period (U.S. DOE/EIA 1996c). The increase in emissions from 1993 through 1995 was also influenced by generally low energy prices, which increased demand for fossil fuels (U.S. DOE/EIA 1996b).

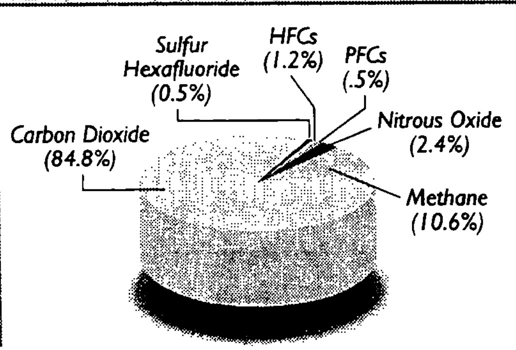
Among the inventory's greenhouse gases, changes in CO_2 emissions from fossil fuel consumption had the greatest impact during the five-year period. In most cases, emissions from methane, N_2O, HFCs, PFCs, and sulfur hexafluoride (SF_6) have remained relatively constant or have increased slightly. For example, methane emissions increased by just over 4 percent The rise in HFC, PFC, and SF_6 emissions, although a small portion of the total, is significant because of their extremely high global warming potentials and, in the cases of PFCs and SF_6, their long atmospheric lifetimes. Greenhouse gas emissions were partly offset by carbon sequestration in forests.

Figure 3-2 illustrates the relative contributions of the primary greenhouse gases to total U.S. emissions in 1995, with CO_2 emissions accounting for the largest share. The largest change in methane estimates compared to earlier inventories is in the natural gas sector, where emissions have been adjusted upward by more than 75 percent due to improved estimation methods; however, these revised emissions have not changed significantly during 1990–95. Larger landfills, expanded animal populations, and more widespread use of liquid manure management systems increased methane emissions from waste management and agricultural activities. In contrast, improved methane recovery and lower coal production from gassy mines have reduced methane emissions from coal mining.

Figure 3-2

Total 1995 U.S. Greenhouse Gas Emissions

In 1995 CO_2 claimed the largest share of greenhouse gas emissions, principally because of fossil fuel combustion, which accounts for 99 percent of total U.S. CO_2 emissions.



Nitrous oxide emissions rose by just under 10 percent during the period, primarily for two reasons. First, fertilizer use, which accounts for approximately 46 percent of total U.S. N_2O emissions, increased significantly during 1993–95 as farmers planted more acreage and worked to replace nutrients lost in the 1993 floods. And second, emissions from other categories grew slightly as the U.S. economy grew.

HFC, PFC, and SF_6 emissions are increasing, along with their expanded use as substitutes for CFCs and other ozone-depleting compounds being phased out under the terms of the *Montreal Protocol* and Clean Air Act Amendments. Two major contributors to the rise in HFC emissions since 1990 are the use of HFC-134a for mobile air conditioners and the emission of HFC-23 during the production of the refrigerant HCFC-22.

The following sections present the anthropogenic sources of greenhouse gas emissions, briefly discuss emission pathways, summarize the emission estimates, and explain the relative importance of emissions from each source category.

3

The Global Warming Potential Concept

Gases can contribute to the greenhouse effect both directly and indirectly. Direct effects occur when the gas itself is a greenhouse gas; indirect radiative forcing occurs when chemical transformations of the original gas produce a greenhouse gas, or when a gas influences the atmospheric lifetimes of other gases.

The concept of global warming potential (GWP) has been developed to allow scientists and policy-makers to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to other gases. CO_2 was chosen as the reference gas to be consistent with the IPCC guidelines (IPCC/OECD/IEA/UNEP 1995).

All gases in this inventory are presented in units of millions of metric tons of carbon equivalent, or MMTCE. Carbon comprises 12/44 of carbon dioxide by weight. The following equation may be used to convert MMTs of emissions of greenhouse gas (GHG) x to MMTCE:

MMTCE =
(MMT of GHG x)(GWP of GHG x)(12/44)

The GWP of a greenhouse gas is the ratio of global warming, or radiative forcing (both direct and indirect), from one kilogram of a greenhouse gas to one kilogram of CO_2 over a period of time. While any time period may be selected, this report uses the 100-year GWPs recommended by the IPCC and employed for U.S. policymaking and reporting purposes (IPCC 1996).

The GWPs of some selected greenhouse gases are shown here. GWPs are not provided for the photochemically important gases CO, NO_X, NMVOCs, and SO_2 because there is no agreed-upon method to estimate their contributions to climate change, and they affect radiative forcing only indirectly (IPCC 1996).

Global Warming Potential

The higher global warming potential of lower-emitting greenhouse gases significantly increases their contributions to the greenhouse effect. For example, over a 100-year time horizon, nitrous oxide is 310 times more effective than carbon dioxide at trapping heat in the atmosphere.

Gas	GWP (100 Years)
Carbon Dioxide	1
Methane	21
Nitrous Oxide	310
HFC-23	11,700
HFC-125	2,800
HFC-134a	1,300
HFC-143a	3,800
HFC-152a	140
HFC-227ea	2,900
HFC-43-10mme	1,300
CH_4	6,500
C_2F_6	9,200
C_4F_{10}	7,000
C_6F_{14}	7,400
PFCs/PFPEs	7,400
SF_6	23,900

Carbon Dioxide Emissions

The global carbon cycle is composed of large carbon flows and reservoirs. Hundreds of billions of tons of carbon in the form of CO_2 are absorbed by the oceans or trees (sinks) or are emitted to the atmosphere annually through natural processes (sources). When in equilibrium, carbon fluxes among the various reservoirs are roughly balanced.

Since the Industrial Revolution, this equilibrium has been increasingly compromised. Atmospheric concentrations of CO_2 have risen more than 25 percent, principally because of fossil fuel combustion, which accounts for 99 percent of total U.S. CO_2 emissions (Seki and Christ 1995). Changes in land-use and forestry activities can emit CO_2 (e.g., through conversion of forest land to agricultural or urban use) and can act as a sink for—or absorb—CO_2 (e.g., through improved forest management activities).

Table 3-2 summarizes U.S. sources and sinks of CO_2, while the remainder of this section discusses CO_2 emission trends in greater detail.

The Energy Sector

Energy-related activities account for roughly 87 percent of annual U.S. greenhouse gas emissions. Of that share, approximately 85 percent is produced through fossil fuel combustion, and the remaining 15 percent comes from renewable or other energy sources, such as hydropower, biomass, and nuclear energy (Figure 3-3). Energy-related activities other than fuel combustion also emit greenhouse gases (primarily methane), such as those associated with producing, transmitting, storing, and distributing fossil fuels.

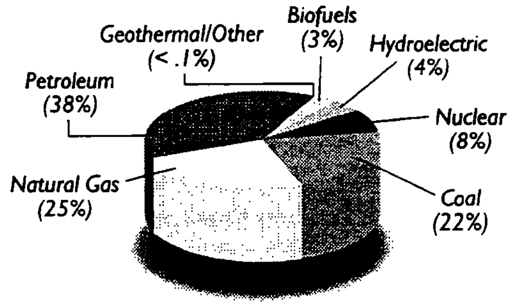
Fossil Fuel Consumption

The amount of carbon in fossil fuels varies significantly by fuel type. For example, coal contains the highest amount of carbon per unit of energy, natural gas has about 45 percent less than coal, and petroleum has about 20 percent less.

Figure 3-3

Sources of U.S. Energy Consumed in 1995

Fossil fuel combustion is the source of approximately 85 percent of the energy consumed in the United States.



Source: U.S. DOE/EIA 1996b

Table 3-2

U.S. Sources of Carbon Dioxide Emissions in 1995
(Millions of Metric Tons)

Sources and Sinks	CO_2 Emissions (Molecular Basis)	CO_2 Emissions (Carbon Equivalent)
Sources	5,214.6	1,422.1
Fossil Fuel Consumption	**5,144.6**	**1,403.1**
Residential	*994.7*	*271.3*
Commercial	*801.6*	*218.6*
Industrial	*1,708.7*	*466.0*
Transportation	*1,600.8*	*436.6*
U.S. Territories	*38.8*	*10.6*
Fuel Production and Processing	**6.2**	**1.7**
Cement Production	**38.5**	**10.5**
Lime Production	**13.6**	**3.7**
Limestone Consumption	**4.4**	**1.2**
Soda Ash Production and Consumption	**5.9**	**1.6**
Carbon Dioxide Manufacture	**1.5**	**0.4**
Sinks	(428.0)	(117.0)
Forestry and Land Use*	**(428.0)**	**(117.0)**
Total Emissions	**5,214.6**	**1,422.2**
Net Emissions	**4,786.6**	**1,305.2**

* *These estimates for the conterminous United States are interpolated from forest inventories in 1987 and 1992 and from projections through 2040. The methodology reflects long-term averages, rather than specific events in any given year (Birdsey and Heath 1995).*

Note: The totals provided here do not reflect emissions from bunker fuels used in international transport activities. At its Ninth Session, the Intergovernmental Negotiating Committee instructed countries to report these emissions separately and to exclude them from national totals. U.S. emissions from bunker fuels were approximately 22 MMTCE in 1995.

In 1995, U.S. fossil fuel combustion emitted 1,403 million metric tons of carbon equivalent (MMTCE). Total consumption of fossil fuels during 1990–95 increased at an average annual rate of 1.2 percent, primarily because of economic growth and generally low energy prices.

Overall, emissions from fossil fuel consumption increased during the five-year period. While emissions of CO_2 in 1991 were approximately 1.2 percent lower than the 1990 baseline level, in 1992 they increased by about 1.6 percent above the 1991 levels, thus returning emissions to slightly higher than the 1990 baseline. By 1993, CO_2 emissions from fossil fuel combustion were approximately 2.5 percent higher than in 1990; in 1994, they were about 4.1 percent higher than 1990; and in 1995, they were about 5 percent higher. This trend is largely attributable to changes in total energy consumption resulting from the economic slowdown in the United States in the early 1990s and the subsequent recovery.

Despite the continued increase in natural gas and coal consumption in 1995, the total amount of petroleum used for energy production declined by about 0.2 percent, as somewhat higher prices for crude oil in 1995 led electric utilities and industry to decrease their consumption of petroleum by 32.0 and 1.9 percent, respectively, and to rely more heavily on natural gas, coal, nuclear electric power, and renewable energy. In contrast, consumption of petroleum increased 1.3 percent in the residential and commercial sectors, and about 1.6 percent in the transportation sector.

The energy-related sources of CO_2 emissions included steam production for industrial processes, gasoline consumption for transportation, heating in residential and commercial buildings, and generation of electricity. Petroleum products across all sectors of the economy accounted for about 42 percent of total U.S. energy-related CO_2 emissions; coal, 36 percent; and natural gas, 22 percent.

Industrial Sector. Industry accounts for the largest percentage of U.S. emissions from fossil fuel consumption (Figure 3-4). About two-thirds of these emissions result from producing steam and process heat, while the remaining third results from providing electricity for such uses as motors, electric furnaces, ovens, and lighting.

Transportation Sector. In the same league as the industrial sector, the transportation sector accounts for about 31 percent of U.S. CO_2 emissions from fossil fuel consumption. Virtually all of the energy consumed in this sector comes from petroleum-based products. Nearly two-thirds of the emissions result from gasoline consumption in automobiles and other vehicles. The remaining emissions stem from meeting other transportation demands, including the combustion of diesel fuel for the trucking industry and jet fuel for aircraft.

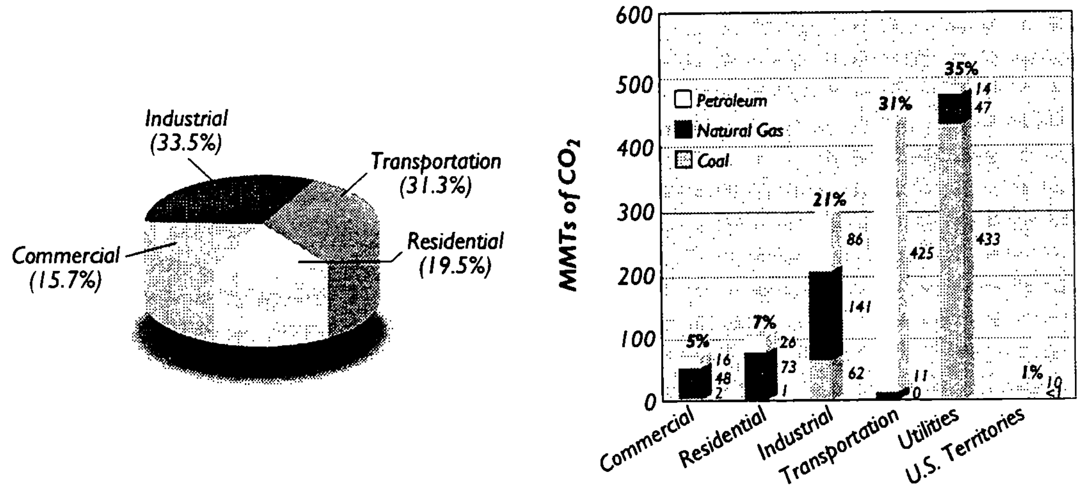
Residential and Commercial Sectors. The residential and commercial sectors account for about 19 and 16 percent, respectively, of CO_2 emissions from fossil fuel consumption. Both sectors rely heavily on electricity for meeting energy needs, with about two-thirds to three-quarters of their emissions attributable to electricity consumption. End-use applications include lighting, heating, cooling, and operating appliances. The remaining emissions are largely due to the consumption of natural gas and oil, primarily for meeting heating and cooking needs.

Electric Utilities. The United States relies on electricity to meet a significant portion of its energy requirements—e.g., lighting, electric motors, and heating and air conditioning. As the largest consumers of U.S. energy (averaging 28 percent), electric utilities are collectively the largest producers (approximately 35 percent) of U.S. CO_2 emissions (Figure 3-5).

The type of energy electric utilities consume directly affects the volume of CO_2 emitted. For example, some of this electricity is generated with low-emitting technologies, Figures 3-4 and 3-5

1995 Sectoral Emissions of CO_2 From Fossil Fuel Combustion

Electricity generation—predominantly produced in coal-fired power plants and used in residential, commercial, and industrial applications—and gasoline-powered transportation jointly account for 5,105.8 MMTs of CO_2



such as nuclear energy, hydropower, and geothermal energy. However, electric utilities rely on coal for over half of their total energy requirements and account for about 87 percent of all coal consumed in the United States. For this reason, changes in electricity demand can significantly affect coal consumption and associated CO_2 emissions.

Fuel Production and Processing

The methane trapped in natural gas systems or oil wells is typically flared to relieve the rising pressure or to dispose of small quantities of gas that are not commercially marketable. As a result, the carbon contained in the methane becomes oxidized and forms CO_2. In 1995, flaring activities emitted approximately 2 MMTCE, or about 0.1 percent of total U.S. CO_2 emissions. Emission trends from fuel production and processing are dictated by fossil fuel consumption.

Biomass and Biomass-Based Fuel Consumption

Biomass fuel is used primarily by the industrial sector in the form of fuelwood and wood waste, while the transportation sector dominates the use of biomass-based fuel, such as ethanol from corn or woody crops. Ethanol and ethanol blends, such as gasohol, are typically used to fuel public transport vehicles.

Although these fuels emit CO_2, in the long run, their emissions do not increase total atmospheric CO_2 because the biomass resources are consumed on a sustainable basis. For example, fuelwood burned one year but regrown the next only recycles carbon, rather than creating a net increase in total atmospheric carbon.

CO_2 emissions from biomass consumption were approximately 51 MMTCE in 1995, with the industrial sector accounting for 72 percent of the emissions, and the residential sector, 25 percent. CO_2 emissions from ethanol use in the United States have been rising in recent years due to a number of factors, including extension of federal tax exemptions for ethanol production, the Clean Air Act Amendments mandating the reduction of mobile source emissions, and the Energy Policy Act of 1992, which established incentives for increasing the use of alternative fuels and alternative-fueled vehicles. In 1995, total U.S. CO_2 emissions from ethanol were 2 MMTCE.

Industrial Processes

Emissions are often produced as a by-product of various nonenergy-related activities. For example, in the industrial sector raw materials are often chemically transformed from one state to another. This transformation often releases such greenhouse gases as CO_2.

The production processes that emit CO_2 include cement production, lime production, soda ash production and use, limestone consumption (e.g., in iron and steel making), and CO_2 manufacture. In 1995, CO_2 emissions from these sources were approximately 10.5, 3.7, 1.6, 1.2, and 0.4 MMTCE, respectively, for a total of 17.4 MMTCE, or about one percent of total U.S. CO_2 emissions. Since 1990, emissions from cement, lime, and CO_2 manufacturing have increased slightly; emissions from limestone use have fluctuated; while emissions from soda ash production remained constant from 1990 through 1994 and increased in 1995.

Cement Production (10.5 MMTCE)

Carbon dioxide is produced primarily during the production of clinker, an intermediate product from which finished Portland and masonry cements are made. Specifically, CO_2 is created when calcium carbonate ($CaCO_3$) is heated in a cement kiln to form lime and CO_2. This lime combines with other materials to produce clinker, while the CO_2 is released into the atmosphere.

Lime Production (3.7 MMTCE)

Lime is used in steel making, construction, pulp and paper manufacturing, and water and sewage treatment. It is manufactured by heating limestone (mostly calcium carbonate—$CaCO_3$) in a kiln, creating calcium oxide (quicklime) and CO_2, which is normally emitted to the atmosphere.

Soda Ash Production and Consumption (1.6 MMTCE)

Commercial soda ash (sodium carbonate) is used in many consumer products, such as glass, soap and detergents, paper, textiles, and food. During the manufacturing of these products, natural sources of sodium carbonate are heated and transformed into a crude soda ash, in which CO_2 is generated as a by-product. In addition, CO_2 is released when the soda ash is consumed.

Limestone Consumption (1.2 MMTCE)

Limestone is a basic raw material used by a wide variety of industries, including the construction, agriculture, chemical, and metallurgical industries. For example, limestone can be used as a purifier in refining metals. In the case of iron ore, limestone heated in a blast furnace reacts with impurities in the iron ore and fuels, generating CO_2 as a by-product. Limestone is also used in flue-gas desulfurization systems to remove sulfur dioxide from the exhaust gases.

Carbon Dioxide Manufacture (0.4 MMTCE)

CO_2 is used in many segments of the economy, including food processing, beverage manufacturing, chemical processing, crude oil products, and a host of industrial and miscellaneous applications. For the most part, the CO_2 used in these applications will eventually be released into the atmosphere.

Changes in Forest Management and Land Use

How the Earth's land resources are managed can alter the natural balance of trace gas emissions. Everyday land-use decisions include clearing an area of forest to create cropland or pasture, restocking a logged forest, draining a wetland, or allowing a pasture to revert to a grassland or forest.

Forests, which cover about 295 million hectares (737 million acres) of U.S. land in the contiguous 48 states (USDA/USFS 1990), are also an important terrestrial sink for CO_2. Because approximately half the dry weight of wood is carbon, as trees add mass to trunks, limbs, and roots, carbon is stored in relatively long-lived biomass instead of being released to the atmosphere. Soils and vegetative cover also provide potential sinks for carbon emissions.

In the United States improved forest-management practices and the regeneration of previously cleared forest areas have resulted in a net uptake (sequestration) of carbon in U.S. forest lands. This uptake is an ongoing result of land-use changes in previous decades. For example, because of improved agricultural productivity and the widespread use of tractors, the rate of clearing forest land for crop cultivation and pasture slowed greatly in the late 19th century, and by 1920 this practice had all but ceased. As farming expanded in the Midwest and West, large areas of previously cultivated land in the East were brought out of crop production, primarily between 1920 and 1950, and were allowed to revert to forest land or were actively reforested.

Since the early 1950s, the managed growth of private forest land in the East has nearly doubled the biomass density there. The 1970s and 1980s saw a resurgence of federally sponsored tree-planting programs (e.g., the Forestry Incentive Program) and soil conservation programs (e.g., the Conservation Reserve Program), which have focused on reforesting previously harvested lands, improving timber-management, combating soil erosion, and converting marginal cropland to forests.

As a result of these activities, the net CO_2 flux in 1995 is estimated to have been an uptake of 117 MMTCE (which includes the carbon stored both in the U.S. wood product pool and in landfills). This carbon uptake represents an offset of about 8 percent of the 1995 CO_2 emissions from fossil fuel combustion during this period. The amount of carbon sequestered through changes in U.S. forestry and land-use practices continues to decline, however, as the expansion of eastern forest cover slows down.

Methane Emissions

Atmospheric methane (CH_4) is an integral component of the greenhouse effect, second only to CO_2 as an anthropogenic source. Methane's overall contribution to global warming is large because it is estimated to be twenty-one times more effective at trapping heat in the atmosphere than CO_2 over a 100-year time horizon (IPCC 1996).

Over the last two centuries, methane's concentration in the atmosphere has more than doubled. Scientists believe these atmospheric increases are largely due to increasing emissions from anthropogenic sources, such as landfills, agricultural activities, fossil fuel combustion, coal mining, the production and processing of natural gas and oil, and wastewater treatment (Figure 3-6 and Table 3-3).

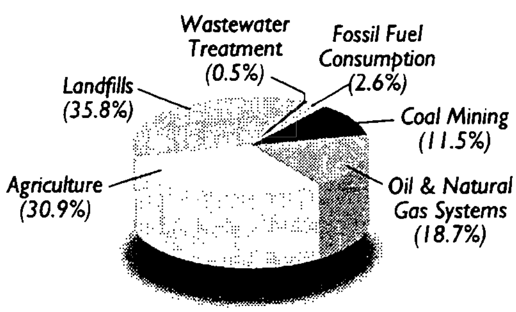
Landfills

Landfills are the largest single anthropogenic source of methane emissions in the United States. Of the estimated 3,000 methane-emitting landfills in the United States, 1,300 account for about half of the emissions.

In an environment where the oxygen content is low or nonexistent, organic materials, such as yard waste, household waste, food waste, and paper, are decomposed by bacteria to produce methane, CO_2, and stabilized organic materials (materials that cannot be decomposed further). Methane emissions from landfills are affected by such specific factors as waste composition, moisture, and landfill size.

Figure 3-6, Table 3-3

U.S. Sources of Methane Emissions in 1995



Sources	MMT	MMTCE
Landfills	11.1	63.5
Agriculture*	9.6	54.8
Oil and Natural Gas Systems	5.8	33.2
Coal Mining	3.6	20.4
Fossil Fuel Consumption	0.8	4.6
Wastewater Treatment	0.2	0.9
Total	31.0	177.3

** One-year data were used to estimate methane emissions from rice cultivation as part of the agricultural sector. Corresponding values for this sector using the IPCC-recommended three-year averages for rice cultivation are: 9.3 MMT and 53.2 MMTCE.*

Note: All methane emission estimates are preliminary.

Methane emissions from U.S. landfills in 1995 were 63.5 MMTCE, a slight increase over the 60 MMTCE reported in the previous inventory. Emissions from U.S. municipal solid waste landfills, which received over 59 percent of the total solid waste generated in the United States, accounted for about 90–95 percent of total landfill emissions, while industrial landfills accounted for the remaining 5–10 percent. Currently, almost 15 percent of the methane released is recovered for use as energy, compared to 10 percent reported in the last inventory.

A regulation promulgated in March 1996 requires the largest U.S. landfills to collect and combust their landfill gas, to reduce emissions of nonmethane volatile organic compounds (VOCs). It is estimated that by the year 2000, this regulation will have reduced landfill methane emissions by more than 50 percent (6.2 MMT of methane, or 35.5 MMTCE).

Agriculture

The agricultural sector accounted for approximately 31 percent of total U.S. methane emissions in 1995, with enteric fermentation in domestic livestock (34.9 MMTCE) and manure management (17.1 MMTCE) together accounting for the majority (Figure 3-7). Other agricultural activities contributing directly to methane emissions include rice cultivation (2.8 MMTCE) and field burning of agricultural crop wastes (0.04 MMTCE).

Between 1990 and 1995, methane emissions from domestic livestock enteric fermentation and manure management increased by about 7 percent and 15 percent, respectively. During this same time period, methane emissions from rice cultivation increased by about 10 percent, while emissions from field burning fluctuated. Several other agricultural activities, such as irrigation and tillage practices, may contribute to methane emissions. However, since emissions from these sources are uncertain and are believed to be small, the United States has not included them in the current inventory. Details on the emission pathways included in the inventory follow.

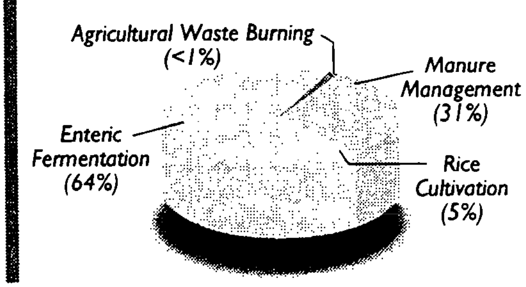
Enteric Fermentation in Domestic Livestock (34.9 MMTCE)

During animal digestion, methane is produced through a process referred to as enteric fermentation, in which microbes that reside in animal digestive systems break down the feed consumed by the animal. In 1995, enteric fermentation was the source of about 20 percent of total U.S. methane emissions, and about 64 percent of methane emissions from the agricultural sector. This estimate of 34.9 MMTCE is the same as that reported in the previous inventory.

Figure 3-7

U.S. Sources of Agricultural Methane Emissions in 1995

Enteric fermentation in domestic livestock and manure management account for the majority of agricultural methane emissions in the United States.



Manure Management (17.1 MMTCE)

The decomposition of organic animal waste in an anaerobic environment produces methane. The most important factor affecting the amount of methane produced is how the manure is managed, since certain types of storage and treatment systems promote an oxygen-free environment. In particular, liquid systems tend to produce a significant quantity of methane, whereas solid waste management approaches produce little or no methane. Higher temperatures and moist climate conditions also promote methane production.

Emissions from manure management were about 10 percent of total U.S. methane emissions in 1995, and about 31 percent of methane emissions from the agriculture sector. Liquid-based manure management systems accounted for over 80 percent of total emissions from animal wastes. The 17.1 MMTCE estimate reported here is slightly above the 13.7 MMTCE reported in the previous inventory because of larger U.S. farm animal populations and expanded use of liquid manure management systems.

Rice Cultivation (2.8 MMTCE)

Most of the world's rice, and all of the rice in the United States, is grown on flooded fields. The soil's organic matter decomposes under the anaerobic conditions created by the flooding, releasing methane to the atmosphere, primarily through the rice plants.

In 1995, rice cultivation was the source of less than 2 percent of total U.S. methane emissions, and about 5 percent of U.S. methane emissions from agricultural sources. Emission estimates from this source have not changed significantly since 1990.

Field Burning of Agricultural Wastes (0.04 MMTCE)

Farming systems produce large quantities of agricultural crop wastes. Disposal systems for these wastes include plowing them back into the field; composting, landfilling, or burning them in the field; using them as a biomass fuel; or selling them in supplemental feed markets.

Burning crop residues releases a number of greenhouse gases, including CO_2, methane, carbon monoxide, nitrous oxide, and oxides of nitrogen. Field burning is not considered to be a net source of CO_2 emissions because the CO_2 released is reabsorbed by crop regrowth during the next growing season. However, this practice is a net source of emissions for the other gases, since their emissions would not have occurred had the wastes not been combusted.

Because field burning is not common in the United States, it was responsible for only 0.02 percent of total U.S. methane emissions in 1995, and 0.07 percent of emissions from the agricultural sector. Estimates of emissions from this source have dropped significantly since the last inventory as a result of new research indicating that a smaller fraction of U.S. crop wastes is burned than previously assumed.

Oil and Natural Gas Production and Processing

Methane emissions vary greatly from facility to facility. In 1995, an estimated 31.2 MMTCE (or approximately 18 percent) of U.S. methane emissions were due to leaks, disruptions, etc., in the operation and maintenance of equipment in the U.S. natural gas system. This figure is significantly higher than previous estimates because of revised estimation methods that improved activity factors (i.e., equipment counts) and emission factors. As a result, natural gas systems are now ranked as the third largest source of U.S. methane emissions.

Natural gas is often found in conjunction with oil exploration. Methane is also released during the production, refinement, transportation, and storage of crude oil. During 1995, oil and gas production and processing facilities released 2.0 MMTCE of methane to the atmosphere, representing about one percent of total U.S. methane emissions.

Coal Mining

Produced millions of years ago during the formation of coal, methane is trapped within coal seams and surrounding rock strata. The volume of methane released to the atmosphere during coal-mining operations depends primarily upon the depth and type of coal being mined.

Methane from surface mines is emitted directly to the atmosphere as the rock strata overlying the coal seam are removed. Because methane in underground mines is explosive at concentrations of 5–15 percent in air, most active underground mines are required to circulate large volumes of air and vent the air into the atmosphere. At some mines, methane-recovery systems may supplement these ventilation systems to ensure mine safety. U.S. recovery of methane for energy has been increasing in recent years.

During 1995, coal mining, processing, transportation, and consumption activities produced an estimated 20.4 MMTCE of methane, or 12 percent of total U.S. methane emissions. This lower estimate is the result of improved mine-specific information and expanded methane recovery.

Other Sources of Methane

Methane is also produced from several other sources in the United States, including energy-related combustion activities, wastewater treatment, industrial processes, and changes in land use. The sources included in the U.S. inventory are fuel combustion and wastewater treatment, which accounted for approximately 4.6 and 0.9 MMTCE, respectively, in 1995. These emissions represent about 3 percent of total U.S. methane emissions. Additional U.S. anthropogenic sources of methane—such as ammonia, coke, iron, and steel production and land-use changes—are not included because little information on methane emissions from these sources is currently available.

Nitrous Oxide Emissions

Nitrous oxide (N_2O) is a chemically and radiatively active greenhouse gas that is produced naturally from a variety of biological sources in soil and water. While N_2O emissions are much lower than CO_2 emissions, N_2O is approximately 310 times more powerful than CO_2 at trapping heat in the atmosphere over a 100-year time horizon (IPCC 1996).

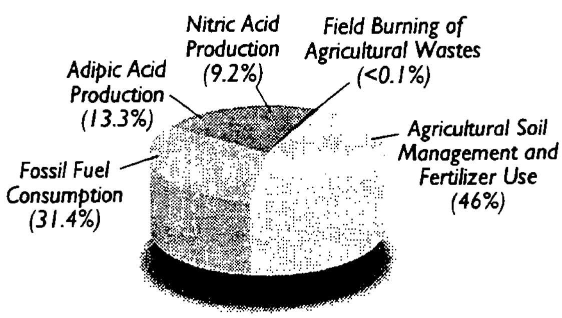
During the past two centuries, human activities, such as those presented in Figure 3-8 and Table 3-4 have raised atmospheric concentrations of N_2O by approximately 8 percent. While emissions from soil management and fertilizers remained relatively constant during 1990–93, they increased during 1994–95 because of intensified fertilizer applications to speed the recovery of nutrients lost to the 1993 floods. N_2O emissions from all other sources showed no significant changes.

Agricultural Soil Management and Fertilizer Use

In 1995, U.S. consumption of synthetic nitrogen and organic fertilizers accounted for 18.4 MMTCE, or approximately 46 percent, of total U.S. N_2O emissions. Other agricultural soil management practices, such as irrigating, tilling, or laying fallow the land, can also affect N_2O fluxes to and from the soil. However, because there is much uncertainty about the direction and magnitude of the effects of these other practices, only the emissions from fertilizer use and field burning

Figure 3-8, Table 3-4

U.S. Sources of Nitrous Oxide Emissions in 1995



Sources	MMT	MMTCE
Agricultural Soil Management and Fertilizer Use	0.21	18.4
Fossil Fuel Consumption	0.15	12.3
Adipic Acid Production	0.06	5.2
Nitric Acid Production	0.04	3.6
Agricultural Waste Burning	< 0.01	< 0.1
Total	0.47	39.5

of agricultural wastes are included in the U.S. inventory at this time.

Fossil Fuel Combustion

N_2O is a product of the reaction that occurs between nitrogen and oxygen during fossil fuel combustion. Both mobile and stationary sources of combustion emit N_2O, and the volume emitted varies according to the type of fuel, technology, or pollution control device used, as well as maintenance and operation practices.

For example, catalytic converters installed to reduce vehicular pollutants have unintentionally promoted the formation of N_2O. As the number of catalytic converter-equipped vehicles has risen in the U.S. motor vehicle fleet, so have emissions of N_2O from this source (DOE/EIA 1993b).

In 1995, N_2O emissions from mobile sources totaled 9.2 MMTCE (or 23 percent of total N_2O emissions), and total N_2O emissions from stationary sources were 3.0 MMTCE.

Adipic Acid Production

The vast majority of all adipic acid produced in the United States is used to manufacture nylon 6,6. N_2O is also used to produce some low-temperature lubricants and to add a "tangy" flavor to foods.

In 1995, U.S. adipic acid production generated 5.2 MMTCE of N_2O, or 13 percent of total U.S. N_2O emissions. By 1996, all adipic acid production plants in the United States. are expected to have N_2O controls in place that will reduce emissions up to 98 percent, compared to uncontrolled levels. (One-half of the plants had these controls in place and operating in 1995.)

Nitric Acid Production

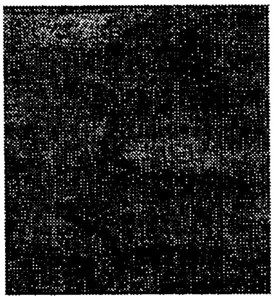
Nitric acid production is another industrial source of N_2O emissions. Used primarily to make synthetic commercial fertilizer, this raw material is also a major component in the production of adipic acid and explosives.

Virtually all of the nitric acid manufactured commercially in the United States is produced by the oxidation of ammonia, during which N_2O is formed and emitted to the atmosphere. In 1995, about 3.6 MMTCE of N_2O were emitted from nitric acid production, accounting for 9 percent of total U.S. N_2O emissions.

Other Sources of N_2O

Other N_2O-emitting activities include the burning of agricultural crop residues and changes in land use. In 1995 agricultural burning contributed approximately 0.01 MMTCE of N_2O emissions to the atmosphere.

The U.S. inventory does not account for several land-use changes because of uncertainties in their effects on fluxes in N_2O and trace gases, as well as poorly quantified statistics on them. These changes include forestry activities, reclamation of freshwater wetland areas, conversion of grasslands to pasture and cropland, and conversion of managed lands to grasslands.



HFCs, PFCs, and SF_6 Emissions

Hydrofluorocarbons (HFCs) and perfluorinated compounds (PFCs) have been introduced as alternatives to the ozone-depleting substances being phased out under the *Montreal Protocol* and Clean Air Act Amendments of 1990. Because HFCs and PFCs are not directly harmful to the stratospheric ozone layer, they are not controlled by the *Montreal Protocol*.

However, these compounds, along with sulfur hexafluoride (SF_6), are powerful greenhouse gases. Therefore, they are considered under the United Nations' Framework Convention on Climate Change (FCCC). In

Table 3-5

1995 Emissions of HFCs, PFCs, and SF_6

HFCs, PFCs, and SF_6 are powerful greenhouse gases. In addition to having high global warming potentials, SF_6 and most PFCs have extremely long atmospheric lifetimes, resulting in their essentially irreversible accumulation in the atmosphere.

Compounds	MMTs of Gas	Atmospheric Lifetime (yrs.)	Global Warming Potential	MMTCE
HFCs	**0.02071**			**20.92**
HFC-23	0.00426	264	11,700	13.61
HFC-125	0.00227	33	2,800	1.74
HFC-134a	0.01086	15	1,300	3.85
HFC-143a	0.00004	48	3,800	0.05
HFC-152a	0.00091	2	140	0.03
HFC-227	0.00186	37	2,900	1.47
HFC-4310	0.00051	17	1,300	0.18
PFCs	**0.00410**			**7.93**
CF_4	0.00250	50,000	6,500	4.43
C_2F_6	0.00057	10,000	9,200	1.42
C_4F_{10}	0.00001	2,600	7,000	0.02
C_6F_{14}	< 0.00001	3,200	7,400	< 0.01
PFCs/PFPEs*	0.00102		7,400	2.05
SF_6	**0.0129**	**3,200**	**23,900**	**8.40**

* *PFC/PFPEs are a proxy for many diverse PFCs and perfluoropolyethers (PFPEs), which are beginning to be used in solvent applications. Global warming potential and lifetime values are based upon C_6F_{14}.*

3

Emissions of CFCs and Related Compounds

Chlorofluorocarbons (CFCs) and other halogenated compounds were first emitted into the atmosphere this century. This family of human-made compounds includes CFCs, halons, methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These substances are used in a variety of industrial applications, including foam production, refrigeration, air conditioning, solvent cleaning, sterilization, fire extinguishing, paints, coatings, other chemical intermediates, and miscellaneous uses (e.g., aerosols and propellants).

Because these compounds have been shown to deplete stratospheric ozone, they are typically referred to as ozone-depleting substances (ODSs). In addition, they are important greenhouse gases because they block infrared radiation that would otherwise escape into space (IPCC 1996).

Recognizing the harmful effects of these compounds on the atmosphere, in 1987 many governments signed the *Montreal Protocol on Substances That Deplete the Ozone Layer* to limit the production and consumption of a number of them. As of April 1997, 155 countries have signed the *Montreal Protocol*. The United States furthered its commitment to phase out these substances by signing and ratifying the *Copenhagen Amendments to the Montreal Protocol* in 1992. Under these amendments, the United States committed to eliminating the production of halons by January 1, 1994, and CFCs by January 1, 1996.

The IPCC Guidelines do not include reporting instructions for emissions of ODSs because their use is being phased out under the *Montreal Protocol*. Nevertheless, because the United States believes that no inventory is complete without these emissions, estimates for emissions from several Class I and Class II ODSs are provided here. Compounds are classified according to their ozone-depleting potential and must adhere to a distinct set of phase-out requirements under the *Montreal Protocol*.

Class I compounds are the primary ODSs; Class II compounds include partially halogenated chlorine compounds (HCFCs), some of which were developed as interim replacements for CFCs. Because these HCFC compounds are only partially halogenated, their hydrogen-carbon bonds are more vulnerable to oxidation in the troposphere and, therefore, pose only about one-tenth to one-hundredth the threat to stratospheric ozone, compared to CFCs.

Also, the effects of these compounds on radiative forcing are not provided here. Although CFCs and related compounds have large direct global warming potentials, their indirect effects are believed to be negative and, therefore, could significantly reduce the magnitude of their direct effects (IPCC 1992). Given the uncertainties surrounding the net effect of these gases, they are reported here on a full molecular weight basis only.

U.S. Emissions of Ozone-Depleting Substances and Related Compounds: 1997
(Millions of Metric Tons)

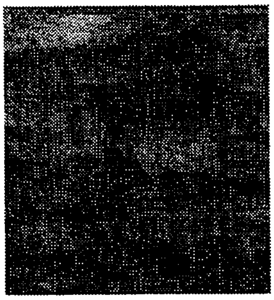
Compound	Emissions
Class I Compounds	
CFC-11	0.036
CFC-12	0.052
CFC-113	0.017
CFC-114	0.002
CFC-115	0.003
Carbon Tetrachloride	0.005
Methyl Chloroform	0.046
Halon-1211	0.001
Halon-1301	0.002
Class II Compounds	
HCFC-22	0.092
HCFC-123	0.002
HCFC-124	0.005
HCFC-141b	0.019
HCFC-142b	0.020

addition to having high global warming potentials, SF_6 and most PFCs have extremely long atmospheric lifetimes, resulting in their essentially irreversible accumulation in the atmosphere.

From 1990 to 1993, U.S. emissions of HFCs and PFCs remained relatively constant, while SF_6 emissions increased slightly. Since 1993, the use and emissions of HFC substitutes have grown largely from an increase in the use of HFC-134a in mobile air conditioners. HFC and PFC emissions also result as by-product emissions from other production processes. For example, HFC-23 is a by-product emitted during the production of HCFC-22, and PFCs (CF_4 and C_2F_6) are emitted during aluminum smelting.

Sulfur hexafluoride (SF_6) is the most potent greenhouse gas the IPCC has ever evaluated. About 80 percent of the worldwide use of SF_6 is as an insulator in electrical transmission and distribution systems. SF_6 is also used as a protective atmosphere for the casting of molten magnesium.

Table 3-5 presents emission estimates for these gases. In 1995, U.S. emissions of HFCs and PFCs were estimated to be 29 MMTCE, and SF_6SF_6 emissions, approximately 8 MMTCE.



Emissions of Criteria Pollutants

In the United States, carbon monoxide (CO), nitrogen oxides (NO_X), nonmethane volatile organic compounds (NMVOCs), and sulfur dioxide (SO_2) are commonly referred to as "criteria pollutants." CO is produced when carbon-containing fuels are burned incompletely. Oxides of nitrogen (NO and NO_2) are created by lightning, fires, and fossil fuel combustion, and in the stratosphere from nitrous oxide. NMVOCs—which include such compounds as propane, butane, and ethane—are emitted primarily from transportation and industrial processes, as well as from forest wildfires and nonindustrial consumption of organic solvents. And SO_2 can result from the combustion of fossil fuels, industrial processing (particularly in the metals industry), waste incineration, and biomass burning (U.S. EPA 1996).

Because of their contribution to the formation of urban smog (and acid rain in the case of SO_2), criteria pollutants are regulated under the 1970 Clean Air Act and its successive amendments. These gases also affect

Sources and Effects of Sulfur Dioxide

Emitted into the atmosphere through natural and human processes, SO_2 affects the Earth's radiative budget through photochemical transformation into sulfate particles that (1) scatter sunlight back to space, thereby reducing the radiation reaching the Earth's surface; (2) possibly increase the number of cloud condensation nuclei, thereby potentially altering the physical characteristics of clouds; and (3) affect atmospheric chemical composition—e.g., atmospheric ozone—by providing surfaces for heterogeneous chemical processes. As a result of these activities, the effect of these gases on radiative forcing may be negative (IPCC 1996), although the distribution is not uniform.

SO_2 is also a major contributor to the formation of urban smog, which can significantly increase in acute and chronic respiratory diseases. Once SO_2 is emitted, it is chemically transformed in the atmosphere and returns to the Earth as the primary source of acid rain. Because of these harmful effects, the United States has regulated SO_2 emissions in the Clean Air Act of 1970 and its subsequent 1990 amendments.

Electric utilities are the largest source of SO_2 emissions in the United States, accounting for about 66 percent of total SO_2 emissions in 1995. Coal combustion contributes approximately 96 percent of those emissions. SO_2 emissions have significantly decreased in recent years, as electric utilities have increasingly switched to lower-sulfur coal and natural gas. The second largest source is fuel combustion for metal smelting and other industrial processes, which produced about 20 percent of 1995 SO_2 emissions (U.S. EPA/OAQPS 1996).

global climate, although their impact is limited because their radiative effects are indirect. That is, they do not directly act as greenhouse gases, but react with other chemical compounds in the atmosphere to form compounds that are greenhouse gases. Unlike other criteria pollutants, SO_2 emitted into the atmosphere affects the Earth's radiative budget negatively; therefore, it is discussed separately from the other criteria pollutants in this section.

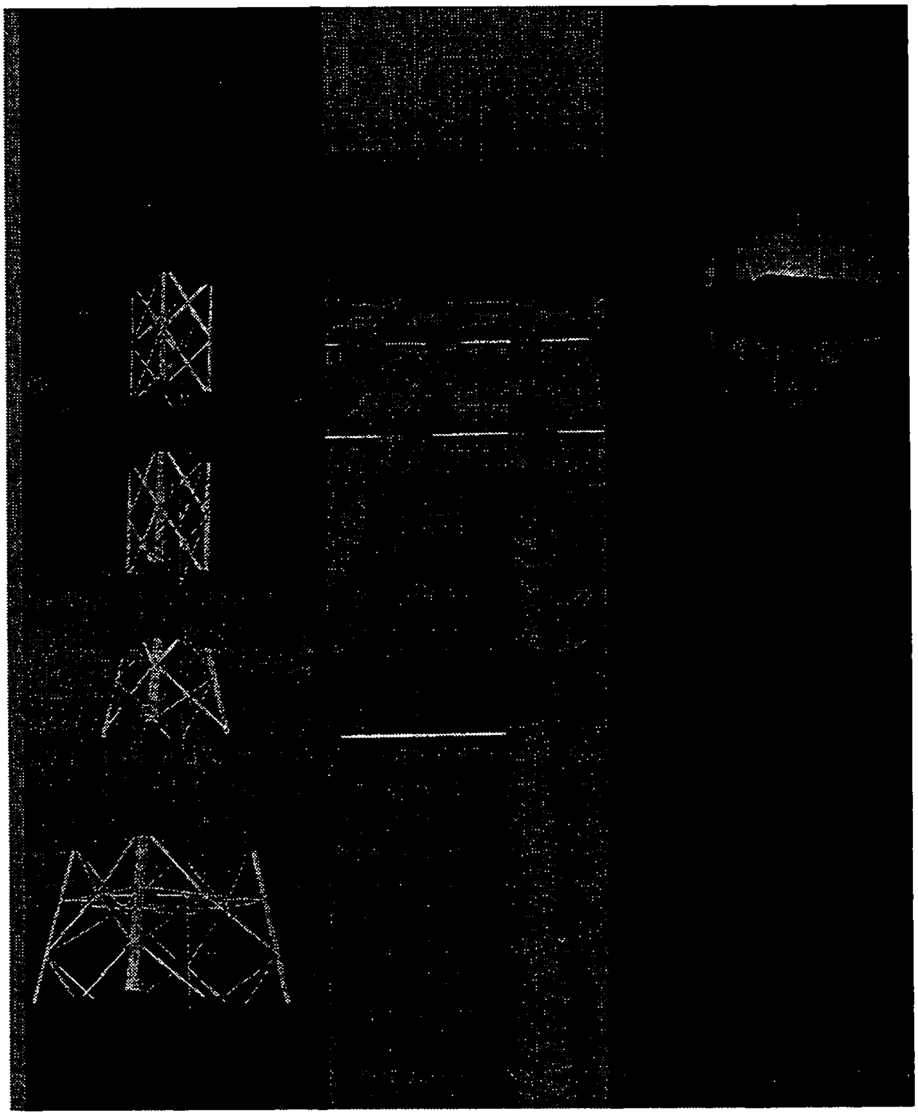
The most important of the indirect effects of criteria pollutants is their role as precursors of tropospheric ozone. In this role, they contribute to ozone formation and alter the atmospheric lifetimes of other greenhouse gases. For example, CO interacts with the hydroxyl radical (OH)—the major atmospheric sink for methane emissions—to form CO_2. Therefore, increased atmospheric concentrations of CO limit the number of OH compounds available to destroy methane, thus increasing the atmospheric lifetime of methane.

Since 1970, the United States has published estimates of annual emissions of criteria pollutants. Table 3-6 shows that fuel consumption accounts for the majority of emissions of these gases. In fact, motor vehicles that burn fossil fuels contributed approximately 81 percent of all U.S. CO emissions in 1995. Motor vehicles also emit more than a third of total U.S. NO_X and NMVOC emissions. Industrial processes—such as the manufacture of chemical and allied products, metals processing, and industrial uses of solvents—are also major sources of CO, NO_X, and NMVOCs.

Table 3-6

1995 Emissions of CO, NO_X, NMVOCs, and SO_2
(Millions of Metric Tons)

Sources	CO	NO_X	NMVOCs	SO_2
Fossil Fuel Combustion	70.95	18.75	8.22	14.73
Industrial Processes	5.15	0.71	4.13	1.83
Solvent Use	< 0.01	< 0.01	5.80	< 0.01
Waste Disposal and Recycling	1.60	0.01	2.19	0.03
Other Combustion	5.86	0.21	0.41	0.01
Total	83.55	19.75	20.74	16.60



The *Climate Change Action Plan* (CCAP), announced by President Clinton and Vice President Gore in October 1993, responds to the threat of global climate change and moves the U.S. economy toward environmentally sound economic growth into the next century.

Studies have shown that there are profitable, low-cost opportunities throughout the United States for reducing greenhouse gas emissions. However, many of these opportunities have gone unrealized, frequently because of informational, regulatory, financial, and institutional barriers that prevent widespread investment in energy efficiency. The CCAP is applying innovative solutions that are beginning to overcome many of these barriers, aligning market forces with the environmental imperative to reduce greenhouse gas emissions. Although originally focused on important early reductions by the year 2000, the CCAP is building emission reductions that grow over time and provide even larger benefits in later years.

The 1993 CCAP consists of over forty programs that are combining a variety of public- and private-sector approaches aimed at reducing emissions profitably while stimulating greater energy efficiency, commercializing renewable-energy technologies, and improving U.S. industrial, agricultural, and forest productivity. Through CCAP programs the United States is:

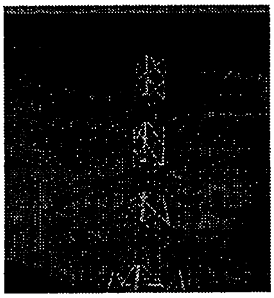
mitigating climate change

- *Preserving the Environment*—The 1993 CCAP is comprehensively addressing all major greenhouse gases in all sectors of the economy. Additional environmental benefits include preventing ozone and particulate air pollution and reducing solid and hazardous wastes.
- *Enhancing Economic Growth*—A successful CCAP will reduce energy costs, improve productivity, and generate larger markets for energy-efficient products and services.
- *Building Partnerships*—The CCAP relies heavily on the active voluntary participation of the private sector and other partners to reduce greenhouse gas emissions and generate larger markets for energy-efficient products and services.
- *Involving the Public*—Federal agencies solicited the public's views while developing the CCAP and while preparing this evaluation of the CCAP.
- *Encouraging International Emission Reductions*—Because climate change is a global rather than a national issue, the 1993 CCAP established the U.S. Initiative on Joint Implementation and the U.S. Country Studies Program to help other countries reduce their greenhouse gas emissions cost-effectively.

This chapter summarizes the progress of existing and new CCAP programs and related programs not included in the 1993 CCAP. It then evaluates individual CCAP programs and presents detailed projections of their reductions of carbon dioxide, methane, and other greenhouse gas emissions and the effects of those reductions for 2000, 2010, and 2020. The final portion of this chapter discusses the U.S. Initiative on Joint Implementation.

Projected Impacts of the CCAP in the Year 2000

- **76 MMTCE of annual reductions in greenhouse gas emissions, equivalent to the emissions from 60 million cars.**
- **$10 billion of annual energy bill savings for consumers and businesses, shifting the nation's resources away from unnecessary energy expenditures.**
- **2 quadrillion Btus of energy conserved annually, equivalent to over 300 million barrels of oil, or 100 million tons of coal, or two trillion cubic feet of natural gas.**
- **100,000 tons of annual nitrogen oxide reductions, improving air quality and protecting public health.**



Action Plan Summary Review

In late 1995, the United States initiated a review and update of the 1993 *Climate Change Action Plan* (CCAP). An interagency review group, chaired by the White House Council on Environmental Quality, included participants from the Environmental Protection Agency (EPA) and the Departments of Energy (DOE), Commerce (DOC), Transportation (DOT), and Agriculture (USDA).

Of the twenty-five submissions the group received in response to a public notice in August 1995, some comments addressed a broad range of analytical issues concerning the CCAP review, while others suggested

Highlights of CCAP Program Successes

Many CCAP programs have been highly successful at stimulating participation and achieving measurable energy and cost savings, as well as reducing greenhouse gas emissions.

- Thousands of efficient ENERGY STAR® labeled products are widely available, including computers, home appliances, and residential heating and air-conditioning equipment. In 1996, ENERGY STAR products saved consumers and businesses over $400 million on their energy bills, while reducing greenhouse gas emissions by 1.1 million metric tons of carbon (MMTCE)—equivalent to the emissions that would be generated by about 900,000 cars.
- Companies representing nearly 10 percent of U.S. industrial energy, and utilities representing over one-half of U.S. electric generation use, have pledged to reduce greenhouse gas emissions through the Climate Wise and Climate Challenge programs, respectively.
- Over 2,300 partners in the ENERGY STAR Buildings and Green Lights programs have invested over $1 billion in energy-efficiency improvements, saving over $250 million on their energy bills in 1996.
- As part of its work with more than 125 communities and 35 states, Rebuild America is reducing the $6.5 billion energy bill at colleges and universities across the country.
- USDA programs under the CCAP have led to the planting of trees on 54,634 hectares (135,000 acres) of land.
- In 1996, partners in EPA's Natural Gas STAR program reduced methane leakage from natural gas pipelines by over 1.0 MMTCE.
- Over 1,600 organizations have joined the Motor Challenge program, whose clearinghouse has been responding to more than 800 calls a month for information and technical assistance.
- Companies representing over 90 percent of U.S. primary aluminum production have joined EPA in the Voluntary Aluminum Industrial Partnership.

additional actions for inclusion in the 1993 CCAP update. Comments were also received during a public hearing on September 22, 1995, and a draft version of this review was made available in the *Federal Register* for comment in August 1995.

The comments from the public and the interagency review have formed the basis for this evaluation of the CCAP. The interagency review has reassessed the impacts of all CCAP actions and provides a new, integrated assessment of the 1993 CCAP. As requested in the guidelines of the United Nations Framework Convention on Climate Change (FCCC), this evaluation extends projections to the year 2020, although uncertainties become greater in more distant years.

Each federal agency maintains a set of performance measures and goals for the CCAP programs it administers, to track and assess each program's progress. As part of the interagency review, each agency has reevaluated its performance targets through the end of 1996 and has reassessed the future impact of its programs in light of recent funding cuts.

Based on continual dialogue with program partners and the public, agencies now have much better information with which to evaluate the potential effectiveness of their programs. As part of the interagency review effort, revised program performance estimates were integrated and modeled to determine the comprehensive impact of these programs on fossil fuel emissions.

Evaluation of Plan Actions

The CCAP evaluation built on the work of implementing agencies to track and evaluate their programs. Each federal agency maintains a set of performance measures and goals for the CCAP programs it administers, which is used to track and assess progress for each program on an ongoing basis.

DOE's Office of Energy Efficiency and Renewable Energy conducts a rigorous process to assess both potential benefits of climate change programs and progress on an ongoing basis. Initiated by DOE in the earliest stages of CCAP, this performance, progress, and outcomes activity has been subsumed by subsequent requirements for all government programs under the National Government Performance and Results Act. Specifically, DOE estimates expected carbon emission reductions and other benefits of each program using a variety of methods and conducts an extensive peer review of the estimates and results. In addition, DOE sets annual performance goals and measures progress toward those goals—including tracking partner accomplishments—for each program. This information is incorporated in the DOE Performance Agreement with the President. Specific program goals and accomplishments are available from the individual programs. For example, the *1996 Rebuild America Fall Forum Proceedings* were published, illustrating a number of partner successes. Likewise, DOE published the *Climate Challenge Annual Report*, which includes an account of program achievements.

EPA has established a similar set of rigorous performance measures and goals. EPA monitors and evaluates program accomplishments based on extensive information collection efforts. For example, the Green Lights program has detailed information on investments and energy savings from over fourteen thousand completed energy-efficiency projects that have been made by Green Lights partners, and continually uses the information to improve the program's performance and more accurately assess its future potential. In addition to tracking greenhouse gas emission reductions, EPA monitors technology markets, energy savings, energy-efficiency investments, and partner participation. Targets and projected impacts are based on a combination of work with experts in related fields, partner input, and program experience. EPA's performance measures are included in the National Government Performance and Results Act, as well as in periodic public reports, including the upcoming annual report of EPA's Atmospheric Pollution Prevention Division. Appendix A of this report contains further information on each program's targets, accomplishments, and contacts.

As part of the interagency review, each agency has comprehensively reevaluated its performance targets and has reassessed the future impact of its CCAP programs. Agencies reviewed program performance through the end of 1996 and considered the impact of recent funding cuts. Based on continual dialogue with program partners and the public, agencies now have much better information with which to evaluate the possible future effectiveness of the programs than they did in the past. Revised program performance estimates were integrated and modeled to determine the comprehensive impact of these programs on fossil fuel emissions.

Overview of Progress Toward Meeting CCAP Goals

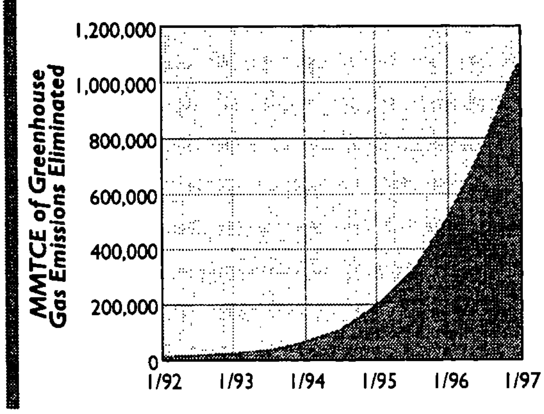
Many 1993 CCAP programs have been successful at establishing partnerships and achieving measurable energy and cost savings. Over five thousand organizations from around the country are participating in CCAP programs, and new partnerships are being formed at a brisk pace. Because of the time needed to develop the programs, build partnerships, and allow partners to make cost-effective investments, it takes most of the programs three to five years to begin to achieve substantial carbon reductions. For example, Figure 4–1 shows the rapidly increasing accomplishments of one of the older voluntary programs—Green Lights, which was launched in 1991. Other, newer programs are following similar pathways, with major reductions expected by 2000 and even greater reductions by 2010 and beyond.

However, for two reasons the 1993 CCAP will not achieve its objective of reducing greenhouse gases to 1990 levels by the year 2000. First, due to such factors as lower-than-expected fuel prices and higher-than-expected economic growth and electricity demand, the analysis used to develop the

Figure 4-1

Green Lights Program Accomplishments

The impacts of many CCAP programs are expected to accelerate as the programs mature.



4

1993 CCAP significantly underestimated the reductions needed to return emissions to 1990 levels by the year 2000. And second, the 1993 CCAP programs have not been fully funded, limiting their effectiveness.

As stated in the 1993 CCAP: "A substantial degree of uncertainty accompanies any attempt to project future emission levels. The analysis supporting the plan represents a best estimate under the most likely scenario, but we recognize that these estimates could vary by a significant degree under other plausible assumptions." The factors that have contributed to higher baseline emission projections are discussed in more detail later in this chapter.

The 1993 CCAP estimated that, assuming full funding, the programs would achieve reductions of 108.6 MMTCE in the year 2000. In 1996 and 1997, however, only 60 percent of the funding requested by the President for the CCAP programs was approved by Congress, as shown in Table 4-1. Based on current funding levels, the revised CCAP is expected to reduce emissions by 76 million metric tons of carbon equivalent (MMTCE) in the year 2000—or 70 percent of the reductions projected in the 1993 CCAP. By the year 2000, the CCAP is expected to save $10 billion in annual energy bills (1995 dollars).

The 1993 CCAP is projected to achieve reductions of about 169 MMTCE in the year 2010 and about 229 MMTCE in 2020. Annual energy savings are projected to grow to $50 billion in the year 2010 (1995 dollars). The projected impact of the CCAP on U.S. greenhouse gas emissions, based on current funding levels, is shown in Figure 4–2. Consistent with the level of uncertainty in the 1993 CCAP, and the difficulty with forecasting longer-term impacts, the analysis supporting the revised CCAP (i.e., this *Climate Action Report*) represents the best estimate of what the programs can achieve. This estimate assumes continuation of funding at least at current levels, as well as continued, aggressive program implementation. President Clinton once again is requesting full funding of CCAP programs for 1998 to achieve greater reductions in greenhouse gas emissions.

Several additional factors contribute to the new projections of CCAP program impacts, including: revised utility forecasts (which alter the impact of projected electricity savings on greenhouse gas emissions);

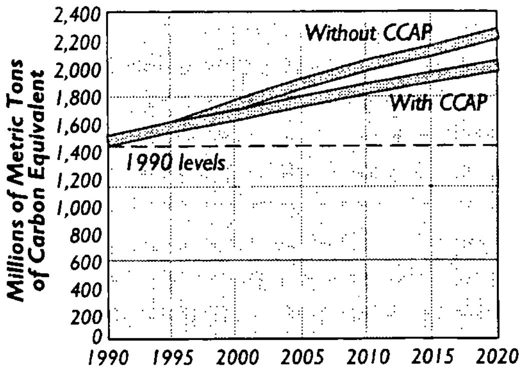
Table 4-1

Action Plan Funding
(Millions of Dollars)

Agency	FY 1995		FY 1996		FY 1997		FY 1998
	President's Request	Appropriation	President's Request	Appropriation	President's Request	Appropriation	President's Request
Department of Energy	$208	$73	$185	$69	$144	$69	$109
Environmental Protection Agency	123	102	138	83	142	86	149
Others	13	9	13	6	19	8	8
Total	$344	$184	$336	$158	$305	$163	$266

Figure 4-2

U.S. Greenhouse Gas Emissions



revised estimates of the relative impact of some gases on global warming (i.e., global warming potentials); and a better understanding of what each program can achieve. Furthermore, legislative riders to recent budget bills have prevented the timely implementation of energy appliance standards (Action 7) and have precluded DOT from pursuing its tire-labeling program (Action 22).

Additions to the Action Plan

In addition to reviewing progress of existing programs, this *Climate Action Report* (CAR) contains six new programs. These actions cover a range of areas, from substantially reducing long-lived perfluorocarbon emissions to expanding market opportunities for energy-efficient light bulbs and windows.

Environmental Stewardship Initiative

This initiative significantly expands activities under Action 40 of the 1993 CCAP (Narrow the Use of High GWP Chemicals). It is designed to limit emissions of perfluorocarbons and hydrofluorocarbons, which are potent greenhouse gases, in the three following industrial applications: semiconductor production, electrical transmission and distribution systems, and magnesium casting.

Emission reductions are believed to be possible through inexpensive and cost-effective means. In all cases, the principles of pollution prevention are being applied to reduce emissions. EPA has initiated a cooperative effort with the semiconductor industry and has begun talks with the electrical and magnesium industries. The combined effect of these new environmental stewardship programs is expected to result in 6.5 MMTCE of reduced emissions by 2000, and 10.0 MMTCE by 2010.

Construction of Energy-Efficient Commercial and Industrial Buildings

Despite the wide availability of reliable, energy-efficient technologies and building designs, most builders and architects are not taking advantage of these energy cost-saving opportunities. Several barriers in the current buildings market are perpetuating the construction of inefficient buildings. Most notably, builders and designers usually do not own and operate their buildings and are therefore not responsible for paying the energy bills. Increasing the construction costs to achieve long-term energy savings, even when there is a quick payback of only a couple of years, is not feasible, unless purchasers and financiers of buildings have clear and reliable information regarding the cost savings they can expect.

Through their Rebuild America and Energy Star Buildings programs, DOE and EPA will work with the financial community and with builders, architects, owners, occupants, and operators to encourage the construction of energy-efficient commercial and industrial buildings. DOE and EPA will also develop a system to differentiate buildings that offer energy cost savings from inefficient buildings. This action is expected to lead to savings of 1.1 MMTCE by 2010.

Expand Markets for Next-Generation Lighting Products

This action will expand markets for energy-efficient lighting products through coordinated federal programs primarily targeting residential lighting. It is based on a comprehensive strategy to convert incandescent lighting to energy-efficient alternatives by delivering a portfolio of lighting products to meet a range of needs over an extended time horizon. The action's objectives are to promote the use and improvement of compact fluorescent lighting (CFL) products; encourage the conversion of high-energy-using fixtures to dedicated CFL fixtures; and fill a key product gap with a low-cost, drop-in replacement for standard incandescent light bulbs. This action is expected to reduce greenhouse gas emissions by 0.2 MMTCE in 2000 and 0.7 MMTCE in 2010.

Superwindow Collaborative

This initiative aims to double the energy efficiency of the average window sold in 2005. It would improve the heating properties of windows sold in cooler climates by increasing their average R (insulating) value, and the cooling properties of windows sold in warmer climates by switching from clear to spectrally selective cool glazings. The strategy is to work with a variety of groups to create the market pull for these products and then help all manufacturers, both small and large, respond to the new market opportunities. This action is expected to yield savings of 0.4 MMTCE by 2010.

Fuel Cells Initiative

DOE is developing a low-cost 50-kilowatt fuel cell that uses reformed natural gas to produce hydrogen fuel to power commercial buildings. While DOE also sponsors fuel cell development as part of its advanced automotive technology program, this action is part of DOE's Space Conditioning program. Four contracts are in place that focus on research and development of fuel cells for buildings: membrane research, natural gas reforming, catalyst development of carbon monoxide tolerance, and bipolar plate development. This action is expected to lead to savings of 0.3 MMTCE by 2010.

Green Power Network

Accessible through DOE's Office of Energy Efficiency and Renewable Energy home page, the Internet-based Green Power Network provides and exchanges information on successful green power programs to encourage electricity suppliers and customers to form green power supply and buyer groups. Green Power Network includes links to utilities, power marketers, public entities, and consumer and environmental organizations that have already developed or are interested in developing green power programs. No emission reductions have been estimated for this action.

Pollution-Prevention Programs Outside of the Action Plan

Although not part of the CCAP, several additional federal policies and programs, state and local government initiatives, and private-sector actions fundamentally contribute to the CCAP's success by providing important emission reductions. These initiatives provide examples of successful strategies, additional impetus for market changes, and enhanced receptivity for CCAP activities. Only a few of the many initiatives by the public and private sectors are identified here as examples.

Non-CCAP Federal Programs

The CCAP builds on important policies and programs authorized by DOE's Energy Policy Act of 1992 (EPAct) that accelerate the development and deployment of renewable-energy technologies, expand efficiency standards and incentives, and encourage the use of alternative fuels in the transportation sector. DOT's Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) provides for improved operation of the transportation system and gives state and local governments increased flexibility in spending federal funds for a variety of projects that would help reduce greenhouse gas emissions. And EPA's Clean Air Act Amendments of 1990 promote enhanced energy conservation and the use of clean fuels, such as natural gas.

Partnership for a New Generation of Vehicles. In an effort to reduce U.S. oil use and cut urban air pollution and carbon dioxide emissions from personal transportation vehicles, in 1993 the Clinton Administration established its Partnership for a New Generation of Vehicles (PNGV). This path-breaking initiative joins the resources of the federal government and its laboratories with those of the U.S. automakers in a new partnership aimed at producing the product and manufacturing innovations needed to significantly enhance fuel efficiency. PNGV's goal is to produce the prototype for a new generation of vehicles that can achieve three times the current fuel efficiency while maintaining performance, utility, and affordability, as well as meeting all present and forthcoming safety and emission requirements. Funding for PNGV across several federal agencies has been provided at the following levels: $263 million in FY 1996, $250 million in FY 1997, and $281 million proposed for FY 1998.

EPA, DOT, and USDA Programs. In 1991, EPA had initiated a set of voluntary programs to conserve energy and reduce greenhouse gas emissions. In the 1993 CCAP, EPA expanded its Green Lights and Energy Star Buildings programs, which increase the energy efficiency of commercial buildings. Also in 1993, EPA expanded its Natural Gas STAR and AgSTAR programs (with USDA), which reduce methane emissions.

USDA expanded both its forest research and management and its fertilizer improvement programs, which decrease greenhouse gas emissions in addition to other benefits. And DOT added activities to its implementation of the ISTEA aimed at improving U.S. ground transportation systems and developing more energy-efficient cars.

DOE Programs. DOE has a long history of developing energy-efficiency and renewable-energy technologies and sponsoring programs that reduce greenhouse gas emissions. These core programs were in place before the 1993 CCAP, and many were expanded in the CCAP. Because they will contribute major greenhouse gas reductions, these programs are a critical component of the U.S. response to climate change.

For years DOE has partnered with the buildings industry, with manufacturers, and with its national laboratories to develop advanced lighting technology, electrochromic windows, high-performance solar water and space-heating systems, and other energy-efficient building technologies. Advanced building designs, more efficient refrigerator compressors and windows, electronic ballasts, and flame-retention heat oil burners installed through 1996 are responsible for net consumer cost savings of over $25 billion.

DOE has also helped industries develop and adopt technologies that are estimated to save $3 billion annually in direct energy costs. Improved diesel engines, industrial system improvements to furnaces, cogeneration, recuperators, computer-controlled ovens, textile hyperfiltration, and irrigation systems are only a few examples from the long list of improvements in industrial energy efficiency that have prevented considerable carbon-equivalent greenhouse emissions from entering the atmosphere. DOE's Industries of the Future program aligns federal investments in technology research, development, and deployment with the needs and expectations of technology users in the private sector. By applying energy-efficiency and renewable-energy technologies to the most energy-intensive industries (pulp and paper, steel, metal casting, glass, aluminum, chemicals, and refining), Industries of the Future is expected to improve U.S. industrial competitiveness by cutting energy costs by over $5 billion by 2010.

In the transportation sector, DOE's Clean Cities program is helping fleet owners in urban areas use alternative vehicles and fuels. By the end of 1995, forty-three cities signed agreements involving more than twelve hundred organizations and half the nation's ozone nonattainment areas, as defined by the Clean Air Act Amendments of 1990. These cities are expected to add more than 300,000 alternative-fuel vehicles by the year 2000. By the end of 1996, an additional ten cities and four hundred participants joined the program. DOE also has considered new designs for electric and other alternative-fuel vehicles.

In the utility sector, DOE has researched and facilitated deployment of photovoltaic systems, biomass power, geothermal electric, wind energy, fuel cells, more efficient coal technology, advanced combined-cycle gas, advanced light water reactors, and other systems that will decrease the level of fossil fuel use.

DOE has initiated a program to develop and demonstrate technologies to maintain the continued safe, reliable, and economic operation of existing U.S. nuclear power plants that will also support possible relicensing for an additional twenty years of operation. The 109 U.S. commercial nuclear power plants currently provide more than one-fifth of the nation's electricity, displacing a substantial amount of greenhouse gas emissions from fossil fuels. Without license renewal of these power plants for an additional twenty years of operation, U.S. nuclear capacity will decline significantly by 2015. This new DOE initiative is working to develop technologies to: (1) inspect, characterize, and manage the effects of aging on nuclear plant systems, structures, and components that affect safety and operation; (2) improve plant operation and control, relieve critical equipment obsolescence issues, and enhance plant performance and economics, while maintaining safety; and (3) reduce the costs and regulatory uncertainties for license renewal.

DOE is currently completing its research and development activities for Nuclear Regulatory Commission certification for next-generation nuclear power plants. Two of the three advanced-technology nuclear plant designs have already been certified and are now available on the international market. DOE's Energy-Related Inventions and Innovations program has funded technology developments that have provided over a half billion dollars in energy savings since the mid-1970s. The Institutional Conservation Programs have helped schools and hospitals make cost-effective improvements in their heating systems and other operations. And with considerable support from the Department of Defense (DOD), DOE has operated the Federal Energy Management Program, which is expected to reduce the energy use of all federal agencies by 20 percent in 2000, potentially saving over $400 million annually.

Private-Sector Initiatives

The active participation of the private sector and other partners is crucial to the 1993 CCAP's success. Beyond their involvement in CCAP programs, companies and organizations throughout the United States are improving their energy and environmental performances in a number of ways:

- Several companies have received widespread recognition for their successful companywide approach to reducing manufacturing energy use. These success stories have encouraged other firms to match their progress.
- Companies that manufacture or market energy-efficient or renewable-energy products or services, and the trade associations that represent them, promote market awareness of the benefits of their products.
- Many industrial and other trade associations have initiatives to promote broader application of efficient and renewable options.
- Several professional societies develop guidelines for energy-efficient practices for everything from lighting to boiler maintenance. They also provide training, conferences, and other venues for reporting on developments in energy efficiency.
- Nonprofit organizations are actively involved in educating the public about the importance of improving energy-efficiency and renewable-energy investments.
- Many collaboratives allow private- and/or public-sector organizations to join forces to improve their energy efficiency. Recent or ongoing partnerships include the establishment of research institutes, bulk-purchase offers for equipment that exceeds currently available efficiency levels, and efforts to overcome specific market barriers.

State and Local Initiatives

In addition to their direct contributions to many 1993 CCAP programs, state and local governments have developed strong energy programs. These initiatives benefit from their two decades of experience as the implementors of the Low-Income Weatherization Assistance Program and the State Energy Program.

State government initiatives address all sectors of the economy and include education and information, technical assistance, energy audit, and research and development programs, as well as financial incentives for efficiency or renewable-energy investments. These initiatives helped to create the widespread energy-efficiency expertise and awareness of services that provided the basis for important demand-side management programs.

Several states have implemented commercial building codes that exceed current national model codes or have added features such as post-construction confirmation of the energy performance of buildings. Local governments may have their own energy offices or may encourage more efficient energy use though their buildings, transportation, economic development, or other support offices.

To build upon state and local initiatives and all of the CCAP's actions, federal officials and state energy offices, environmental agencies, and utility commissions are developing new working relationships. The intent is for the federal government to provide support to states and localities to build expertise in climate change policy issues and to provide a central federal point of contact for greenhouse gas mitigation efforts. States have been involved in the implementation planning process from the beginning, bringing their considerable expertise to these issues, particularly as related to energy efficiency and renewable technologies.

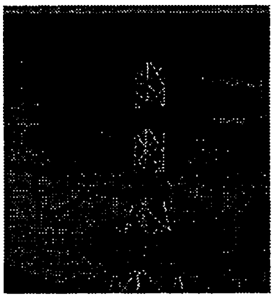
Thirty-five states currently operate industrial and commercial efficiency programs. They have significant expertise working with builders, manufacturers, utilities, public utility commissions (who regulate utilities and natural gas distribution companies), and building owners. For example, many utility demand-side management programs have been initiated through the joint efforts of utilities and state energy offices. State programs have helped hundreds of industrial and commercial energy users to convert from fossil fuels to low-cost biomass and other renewable technologies, have organized photovoltaic technologies to work in new applications, and have coordinated with state regulatory commissions and utilities to implement integrated resource planning, opening up new opportunities for efficiency and renewable technologies.

State and Local Outreach Program

EPA's State and Local Climate Change Outreach Program provides similar support. Its "one-stop shopping" efforts are designed to encourage states and localities to develop and implement cost-effective greenhouse gas reduction strategies in addition to those identified in the 1993 CCAP. The outreach program builds capacity in climate change issues and helps integrate CCAP with other planning efforts, such as the Clean Air Act Amendments of 1990, EPAct, and ISTEA. The program provides technical and financial assistance to states and localities to conduct greenhouse gas inventories, to develop state and city action plans to reduce greenhouse gas emissions, to study the impacts of climate change, and to demonstrate innovative mitigation policies. Other efforts include providing training workshops and guidance documents.

To date, thirty states have prepared or have nearly completed inventories, and twenty have completed or are developing action plans. Forty-one cities have joined the Cities for Climate Protection Campaign, and nearly twenty states and localities have completed projects that range from telecommuting demonstrations to studies of the impact of sea level rise on land use and development policies.

The CCAP did not quantify the impact of the program on emissions because its primary purpose is to build climate change capacity and expertise at the state and local levels. Several successful demonstration projects, however, have been expanded and/or continued, and their reduction potentials have been estimated. Current projections are that the program will reduce greenhouse gas emissions by approximately 1.9 MMTCE in 2000 and 4.2 MMTCE in 2010.



Carbon Dioxide Programs

Carbon dioxide (CO_2) accounted for 85 percent of net U.S. greenhouse gas emissions in 1995. Investing in energy efficiency is the most cost-effective way to reduce CO_2 emissions, often providing energy cost savings that exceed the added first cost of advanced technologies. CCAP combines an array of public–private partnerships to stimulate the deployment of existing energy-efficient technologies and accelerate the introduction of innovative technologies. The goal of these programs is to cut CO_2 emissions, while enhancing productivity domestically and U.S. competitiveness abroad. The following discussion of CCAP programs and initiatives is broken out by economic sector.

The 1993 CCAP included three foundation programs that have broadly involved key sectors in efforts to reduce greenhouse gas emissions. Large portions of the electric utility and industrial sectors have pledged greenhouse gas reductions through the Climate Challenge and Climate Wise programs, respectively. And many state and local governments are working with the federal government on their own greenhouse gas action strategies through the State and Local Outreach Program.

The projected contributions of these programs have been quantified for the first time in this *Climate Action Report*. Because partners in the foundation programs have the flexibility to comprehensively include all of their activities to reduce greenhouse gas emissions, they sometimes include actions taken in conjunction with other programs or actions already anticipated in the 1993 CCAP's development (i.e., in the CCAP's emissions "baseline"). No additional emission reductions were quantified for the foundation programs in the CCAP due in part to the uncertainty regarding the specific activities associated with these commitments. Now, however, the programs have better information on the actions that their partners have pledged and have calculated the expected additional emission reductions from these actions.

Residential and Commercial Sector Actions

In 1995, commercial and residential buildings accounted for 35 percent of total U.S. energy consumption, including 65 percent of all electrical generation (U.S. DOE/EIA 1996a). CCAP programs are working with commercial building owners to reduce energy waste and realize the economic potential of energy-efficiency opportunities. Programs have demonstrated that many existing buildings can achieve average energy savings of 35 percent through an integrated systems approach to energy efficiency. As a result of these programs, companies are lowering their overhead, improving their productivity, and increasing their competitiveness.

CCAP also targets key opportunities in the residential sector, such as the energy efficiency of heating and cooling equipment, home appliances, and lighting and the design of building exteriors. The residential programs include a mix of partnerships with businesses and utilities, as well as new standards and building codes. A typical home built fifteen years ago can be upgraded to save as much as 40 percent of its energy use at a profit to homeowners.

Some significant changes to the commercial and residential programs have been implemented to maximize program effectiveness and respond to changing circumstances. Building on the success of the Green Lights program (Action 2), EPA has integrated the program with its newer Energy Star Buildings program (Action 1). Another program, "Golden Carrot" Market-Pull Partnerships (Action 6), was originally intended to pool utility rebates and use other innovative partnerships to commercialize energy-efficient technologies. However, utility funding of energy-efficiency initiatives has begun to decline since the 1993 CCAP was released. To fulfill the goals of Action 6, EPA and DOE are promoting successful ENERGY STAR® consumer labeling programs, and DOE is facilitating advanced high-efficiency appliances into the marketplace. Finally, DOE has integrated two actions—Home Energy Rating Systems (Action 8) and Residential Energy Efficiency (Action 11)—into its Energy Partnerships for Affordable Housing program. One action—State Revolving Funds for Public Buildings (Action 3)—was canceled due to lack of funding.

Rebuild America *(Action 1)*

DOE is working with community partnerships to identify and achieve cost-effective investments in public housing, commercial, and multifamily residential buildings through improved energy efficiency. Rebuild America programs are based on local needs and priorities, which provides community leaders a high level of flexibility in their program design. Any assembly of companies and organizations may form a partnership. Rebuild America helps its partners by providing a customized set of products and services designed to meet their community's special needs. The partners also receive both local and national recognition for their innovative approaches to community-wide programs. Rebuild America program representatives work with partners' teams to ensure the assistance provided will be timely and effective.

To date, over 125 community partnerships have been formed in thirty-five states and territories. When the upgrades to their floor space are completed, they will result in annual financial savings for building owners and occupants of $1.2 billion and annual energy savings of 100 trillion Btus. The 1993 CCAP projected emission reductions from this action and expansion of the Energy Star Buildings program (below) would be 3.1 MMTCE in 2000. The actions have been realigned to reflect the integration of the Green Lights and Energy Star Buildings programs. Current projections for Rebuild America are 1.6 MMTCE in 2000 and 6.3 MMTCE in 2010.

Green Lights and Energy Star Buildings *(Actions 1 and 2)*

Since the Green Lights program's inception in 1991, EPA has entered into more than 2,300 partnerships with corporations, small business, utilities, nonprofit organizations, and other groups that agree to upgrade lighting equipment with more energy-efficient systems. These lighting system upgrades save, on average, 50 percent of the energy used for lighting, and they provide an average rate of return of 35 percent. Partners have already invested over $1 billion in lighting upgrades, and have made commitments for much larger investments.

EPA's newer Energy Star Buildings program, launched in 1995, leads a building owner through a more comprehensive, five-stage strategy to capitalize on system interactions intended to maximize energy savings at minimum cost. In the 1993 CCAP, the expansion of these programs was expected to yield greenhouse gas reductions of approximately 3.6 MMTCE in 2000. Current projections for the expansion of the programs are 3.3 MMTCE in 2000 and 16.3 MMTCE in 2010. The full programs are expected to achieve even larger reductions.

Cost-Shared Demonstrations of Emerging Technologies *(Action 4)*

DOE has sponsored cost-shared demonstrations of emerging energy-efficient technologies, such as a new laundry waste-water filtration and recycling system. As part of a DOE-initiated consortium of hotel and motel chains, Red Lion Inns hosted a project to test and evaluate the new water- and energy-conserving system. National recycling of 60 percent of the hot water at large institutional laundries can save 20 trillion Btus per year (costing $35 million) and reduce annual demand for water and sewage treatment by 85 billion gallons. Annual chemical cost savings may reach $250 million. Additional demonstrations in progress include innovative sulfur lamp technology in Postal Service and Air Force facilities, advanced dedicated compact fluorescent fixtures and controls for guest rooms in cooperation with Holiday Inns, and evaluation of new horizontal-axis clothes washers in a variety of commercial, institutional, and residential settings.

Combined with Action 5, below, these programs were projected in the 1993 CCAP to yield reductions of approximately 3.8 MMTCE in 2000. Funding for these programs has been significantly reduced from originally anticipated levels. Current projections are that there will be no significant reductions by 2000, with 1.0 MMTCE in reductions in 2010.

Operation, Maintenance, and Training for Commercial Building Facility Managers and Operators *(Action 5)*

DOE will use training programs and the educational infrastructure of the trades in its work to develop an operation and maintenance training curriculum highlighting energy. Once in place, training will be available to new and experienced operators to keep them informed about energy-efficiency improvements for a highly transitory career field. DOE also draws upon the experience of the Federal Energy Management Program, state energy offices, low-income weatherization providers, utilities, and other successful programs currently underway, such as Rebuild America.

Combined with Action 4, these programs were projected in the 1993 CCAP to yield reductions of 3.8 MMTCE in 2000. Funding for these programs has been significantly reduced from originally anticipated levels. Current projections are that there will be no significant reductions by 2000, with 1.0 MMTCE in reductions in 2010.

ENERGY STAR® Products *(Action 6)*

EPA and DOE are using the ENERGY STAR® label to promote products and services that save energy and money and help the environment. The goal of the ENERGY STAR® programs is to increase the market share of energy-efficient products by encouraging consumers to purchase products and homes displaying the ENERGY STAR® label. Over 500 manufacturers currently participate in these programs and are offering over 13,000 product models that qualify for the ENERGY STAR® label. In addition, more than 200 builders and developers have committed to build over 15,000 Energy Star Homes across the nation.

DOE launched "Energy Star Retailer" to promote energy-efficient appliances through point-of-purchase information, product labeling, sales force training, and corporate advertising. DOE also established a program to promote ENERGY STAR® appliances in new homes, initially in cooperation with the manufactured housing industry in the Northwest. DOE is also facilitating volume purchases of efficient appliances that "raise the bar" for ENERGY STAR® levels by demonstrating emerging technologies with buyers' groups. Volume purchases have already resulted in a new apartment-sized refrigerator that is 31 percent more efficient than federal minimum standards, and commitments from public housing authorities to purchase 71,000 of these refrigerators in 1997.

The 1993 CCAP projected this action would yield reductions of approximately 5.0 MMTCE in 2000. Current projections are 4.3 MMTCE in 2000 and 19.4 MMTCE in 2010.

Residential Appliance Standards *(Action 7)*

DOE maintains and improves the efficiency standards for eleven product categories of residential appliances. In so doing, it works with manufacturers, trade associations, environmental groups, utilities, retailers, government agencies, and others in the public rulemaking process.

A congressional moratorium imposed on new standards during 1996 has ended, and DOE expects to issue final rules for improved efficiency standards for refrigerators and room air conditioners before the end of 1997. An Advanced Notice of Proposed Rulemaking for clothes washers is also due out soon.

The 1993 CCAP projected this action would yield reductions of approximately 6.8 MMTCE in 2000. Due to delays in implementing the standards, current projections are 0.2 MMTCE in 2000 and 3.7 MMTCE in 2010.

Energy Partnerships for Affordable Housing *(Actions 8 and 11)*

This action is designed to improve the energy efficiency and affordability of public and privately owned single-family and multifamily housing throughout the nation. Begun as a joint initiative between DOE and the Department of Housing and Urban Development (HUD), Energy Partnerships for

Affordable Housing seeks to establish voluntary collaborations with state and local governments, utilities, and the housing development and financing industries to provide resource-efficient and affordable housing in both new and renovated buildings.

Major program components include: (1) formal partnerships with local public housing authorities to improve large portions of the housing they own and operate; (2) work with community-based housing providers, builders, architects, and associations to incorporate energy- and resource-efficient whole-building criteria design scenarios throughout their communities; (3) close collaboration with retailer program efforts to foster appliance efficiencies; and (4) development of an infrastructure to overcome barriers to energy-efficiency financing through the use of Home Energy Rating Systems.

The major goal of this action is to create local and community partnerships that will collectively commit to installing energy-efficiency improvements in at least one million housing units by 2000. Supporting activities to reach this goal include technical assistance made available to community-based housing providers for the application of whole-building design, rehabilitation specifications that can achieve 20–30 percent efficiency gains over current practice, and assistance to seven pilot states to overcome barriers to financing. Current participants in the action include public housing authorities in Chicago, Atlanta, and Boston; Habitat for Humanity and other community-based housing providers; Home Energy Rating System providers in Alaska, Arkansas, California, Colorado, Mississippi, Vermont, and Virginia; and associations at both national and local levels.

The 1993 CCAP jointly evaluated Actions 8 through 11, which were expected to achieve reductions of 4.4 MMTCE in 2000. Because funding for these programs has been significantly reduced from originally anticipated levels, current projections for them are 0.4 MMTCE in 2000 and 3.3 MMTCE in 2010.

Cool Communities *(Action 9)*

DOE is working with American Forests and the USDA Forest Service to designate "Cool Communities" across the United States. The Cool Communities program provides national recognition to participants and a framework for strategic tree planting and surface-color lightening projects intended to improve local environments. Pilot Cool Communities nationwide are saving money and energy while building civic pride, involving citizens, and winning grants. DOE is working with manufacturers to develop, test, and label reflective surfaces and coatings.

The 1993 CCAP jointly evaluated Actions 8 through 11, which were expected to achieve reductions of 4.4 MMTCE in 2000. Because funding for these programs has been significantly reduced from originally anticipated levels, current projections for them are 0.4 MMTCE in 2000 and 3.3 MMTCE in 2010.

Update State Building Codes *(Action 10)*

Energy standards and guidelines for buildings are effective means of improving energy efficiency because they eliminate inefficient construction practices and technologies. DOE's increased emphasis on successful adoption of these practices has resulted in five hundred training sessions;

more than ten thousand copies of "MEC-check" building code software distributed to more than twenty states; responses to more than 250 requests per month; and nearly four million dollars in financial assistance to twenty-eight states and territories to update and implement their energy-efficient building codes and standards.

The program is on target with thirty-four states meeting EPAct requirements for residential energy codes. In 1996 five new states adopted residential energy codes that meet or exceed the national model energy code. DOE is working with ten states to help them become early adopters of portions of the next generation of the building industry's commercial building consensus standard. In addition, DOE has developed a simple computer program and package compliance approach for assessing compliance with low-rise commercial building standards.

The 1993 CCAP jointly evaluated Actions 8 through 11, which were expected to achieve reductions of 4.4 MMTCE in 2000. Because funding for these programs has been significantly reduced from originally anticipated levels, current projections for them are 0.4 MMTCE in 2000 and 3.3 MMTCE in 2010.

Industrial Sector Actions

The nation's industries were responsible for 42 percent of energy consumption in 1995, including 34 percent of electricity generated. Industry accounts for 34 percent of U.S. CO_2 emissions from fossil fuel consumption. About two-thirds of these emissions results from producing steam and process heat, while the remaining third results from electricity use and related emissions from electric utilities. A small number of major manufacturing groups—primary metals, petroleum refining, chemicals, pulp and paper—account for about two-thirds of industrial energy use and 19 percent of gross domestic product. The 1993 CCAP establishes working partnerships with U.S. industry to help improve energy efficiency and productivity.

The 1993 CCAP's portfolio of industrial programs has been revised to adjust to reduced funding levels and other factors. Although DOE decided to eliminate the Adoption of Energy-Efficient Process Technologies (Action 14), which would have created one-stop shops to disseminate clean technology information through state agencies, Climate Wise is now performing a similar function. Golden Carrot Industrial Programs (Action 13) has been merged into Motor Challenge (Action 12) in response to stakeholder comments for enhanced program access. Reduce Pesticide Use (Action 18) has been terminated due to lack of funding.

Climate Wise *(Foundation Program)*

Climate Wise is working with U.S. industrial companies to turn energy efficiency and environmental performance into a corporate asset. Jointly sponsored by EPA and DOE, Climate Wise works with companies to develop a comprehensive set of cost-effective actions to reduce greenhouse gas emissions. Over 250 companies, representing more than 7 percent of U.S. industrial energy use, are taking such actions as: improving industrial processes, optimizing boiler efficiency, improving air-compressor system performance, eliminating waste heat, launching cogeneration systems, and switching to less carbon intensive fuels. Participating companies already expect to save more than $300 million by 2000 from cost-effective emission reduction actions.

In addition to economic savings, Climate Wise companies receive technical assistance in the form of Action Plan Workshops, Business-to-Business Peer Exchange Working Sessions, consultation assistance through the DOE national labs and through the "Wise Line" Technical Assistance Hotline, and on-site energy and waste assessments through DOE Industrial Assessment Centers. One of the foundation programs in the CCAP, Climate Wise serves as an umbrella program encouraging participation in the full range of CCAP initiatives.

The 1993 CCAP did not quantify the emission reductions expected from this program. Current projections are 1.8 MMTCE in 2000 and 3.7 MMTCE in 2010.

Motor Challenge *(Action 12)*

This voluntary partnership program between DOE and industry promotes the adoption of a systems approach to developing, purchasing, and managing motors, drives, and motor-driven equipment that will increase energy efficiency, enhance productivity, and improve environmental quality. Since two-thirds of the industrial sector's electricity use is for motors, industrial motors use over 20 percent of all U.S. electricity generation.

As of October 1996, over sixteen hundred organizations have joined the program. Motor Challenge Showcase Demonstrations, Industry Partnerships, Allied Partnerships, and Excellence Partnerships are exceeding initial program expectations. DOE has selected twenty-nine ongoing showcase demonstrations, representing an industry investment of $10 million. The estimated annual energy savings represents 100 million kilowatt-hours per year—the equivalent of electricity supplied to over five thousand houses a year. The Showcase Demonstrations bring together motor system users, equipment manufacturers, utility companies, and state energy offices to host the design, engineering, installation, and operation of these projects using technology and engineering to optimize electric motor systems. By 2000, Motor Challenge will generate energy cost savings of $250 million.

The 1993 CCAP projected emission reductions of 8.8 MMTCE in 2000 from this action. Because funding for this program has been significantly reduced from originally anticipated levels, current projections are 1.8 MMTCE in 2000 and 5.8 MMTCE in 2010.

Industrial Assessment Centers *(Action 15)*

Since 1978, DOE has sponsored energy audits for small and medium-sized manufacturers. In 1993, the agency teamed with EPA to expand the Energy Analysis and Diagnostics program to include industrial assessments that result in productivity improvements and waste reduction as well as energy savings. While funding to expand this program under the 1993 CCAP has not been appropriated, the base program is quite active. Industrial Assessment Center program engineering faculty and student teams perform approximately thirty assessments in each of thirty centers each year, for a total of seven thousand energy assessments since 1978, The program has also distributed a "Life Cycle

Costing" manual and "Self Assessment" work book for both small and large plants.

The 1993 CCAP projected emission reductions from the expansion of the Industrial Assessment Centers of 0.5 MMTCE. Due to lack of incremental funding, no emission reductions are currently projected for the intended expansion. However, projected emission reductions for the base program (outside of CCAP) are 1.4 MMTCE in 2000 and 1.9 MMTCE in 2010.

Waste Minimization *(Action 16)*

The United States is expanding voluntary source-reduction, pollution-prevention, and product-recycling programs through three programs. The 1993 CCAP projected emission reductions of 4.2 MMTCE from these programs. Current projections are 4.1 MMTCE in 2000 and 7.0 MMTCE in 2010.

National Industrial Competitiveness Through Energy, Environment, Economics Program. NICE[3] is a DOE cost-shared grant program. In partnership with states and private companies, DOE catalyzes cleaner production and manufacturing processes, reduces wastes in industry, conserves energy and energy-intensive feedstocks, and improves industrial competitiveness. With fiscal year 1997 funds, thirteen projects were selected to produce the next wave of cost-effective, pollution-prevention technologies that will spawn further innovation as project successes come to fruition. The total federal value of current projects is approximately $25 million, with an average private-sector cost share of over $3.50 of private investment per federal dollar. Successful projects are experiencing a 60 percent annual rate of return.

Waste Wi$e. This program addresses three critical environmental and natural resource challenges now facing the country: the reduction of greenhouse gas emissions, the sustainable use of natural resources, and the economical disposal of solid waste. Waste Wi$e has engaged over five hundred businesses to set voluntary waste-prevention and recycling goals that they can achieve cost-effectively and report on progress toward achieving those goals. Waste Wi$e is opening membership to tribal, state, and local governments for the first time in 1997.

While 1996 results are not yet available, in 1995, Waste Wi$e partners conserved nearly 344,000 tons of materials through waste prevention—a 40 percent increase over 1994 reported figures. In addition, partners quadrupled the reported amount of materials collected for recycling to over four million tons. Partners also helped create stronger markets for collected recyclables by purchasing more than two million tons of recycled-content products in 1995.

Expansion of Recycling Technology. This USDA Forest Service program is developing technology to remove barriers to the use of recycled wood and fiber in durable structural products suitable for the housing markets.

Transportation Sector Actions

The combustion of fossil fuels to move people and goods consumed 27 percent of the nation's energy in 1995. The expected increase in demand for transportation services over the next decade will hamper efforts to reduce greenhouse gas emissions and will continue to contribute to urban air pollution and to U.S. reliance on foreign oil. Transportation will be the fastest-growing source of CO_2 emissions through the year 2000. The 1993 CCAP contains a package of initiatives to address growth in transportation sector emissions by slowing the growing demand for vehicle travel and enhancing the market for more efficient technologies and cleaner fuels.

Because the transportation sector represents such a significant source of CO_2 emissions, the 1993 CCAP called for establishing a process to develop measures that would significantly reduce greenhouse gas emissions from personal motor vehicles, including cars and light trucks. The goal of this process was to identify regulatory and nonregulatory measures that would improve fuel efficiency in new vehicles by an amount equivalent to 2 percent per year over ten to fifteen years.

To implement this commitment, President Clinton established a Policy Advisory Committee to Assist in the Development of Measures to Significantly Reduce Greenhouse Gas Emissions from Personal Motor Vehicles. Despite an extensive effort involving representatives from key public- and private-sector interests, this process failed to produce consensus recommendations. As a result, emission reductions from the transportation sector remain a significant challenge to returning total net emissions to 1990 levels.

Cash Value of Parking *(Action 19)*

This action is a change in the Internal Revenue Code section relating to the taxation as income of employer-provided parking. Its goal is to reduce vehicle travel and traffic congestion by providing employees a powerful new incentive to car pool, take transit, or find other ways to get to work. The change requires some employers to offer a cash allowance as an option to tax-exempt parking subsidies as a condition of the tax exemption. Legislation to implement the change was introduced in 1994 as part of the General Agreement on Tariffs and Trade legislation but was not enacted. The 1993 CCAP jointly evaluated Actions 19 through 21, expecting them to achieve reductions of 6.6 MMTCE in 2000. Current projections for these programs are 4.6 MMTCE in 2000 and 10.9 MMTCE in 2010.

Innovative Transportation Strategies *(Action 20)*

This action is expected to broaden the arsenal of strategies available to cities and states seeking to meet the joint challenges of clean air and urban mobility. EPA, in consultation with DOT, is drafting guidance documents that identify the air quality benefits of innovative transportation strategies to reduce vehicle miles traveled.

The United States is aggressively promoting innovative pollution control strategies, concentrating on market mechanisms, such as parking charges, emission-based fees, accelerated vehicle scrapping, and transportation subsidies, to encourage people to drive less. Some states have experimented with innovative programs, such as congestion pricing tolls and mass transit finance. New technologies, such as virtual offices (completely portable communications and computing equipment), smart cars and transit vehicles, and advanced traveler information systems, will be encouraged. This initiative has the potential to reduce the costs of complying with clean air regulations and improve the quality of life of transportation users through increased choice and enhanced environmental quality.

In the 1993 CCAP, Actions 19 through 21 were jointly evaluated and were expected to achieve reductions of 6.6 MMTCE in 2000. Current projections for these programs are 4.6 MMTCE in 2000 and 10.9 MMTCE in 2010.

Telecommuting Program *(Action 21)*

DOT, in collaboration with other agencies, is implementing a federal government pilot telecommuting program that reduces commuter travel by encouraging work-at-home arrangements and by using existing telework centers, which provide generic office facilities closer to employees' homes. Telecommuting is believed to have a large potential for application, based on rapid technological advance in computers and computer links and on the growth of information workers as a proportion of the total labor force.

In April 1994 the Secretary of Transportation issued a formal departmental policy on telecommuting, and in June 1996 President Clinton directed executive departments and agencies to develop plans and expand their abilities to offer employees opportunities to telecommute. In addition, the federal government is promoting increased use of telecommuting by state and local governments and private industry.

In the 1993 CCAP, Actions 19 through 21 were jointly evaluated and were expected to achieve reductions of 6.6 MMTCE in 2000. Current projections for these programs are 4.6 MMTCE in 2000 and 10.9 MMTCE in 2010.

Fuel Economy Labels for Tires *(Action 22)*

DOT will increase vehicle fuel economy by establishing tire labels for the replacement tire market. These labels will be based on a measure of their impacts on vehicle fuel economy (due to rolling resistance). In 1996 and 1997, Congress specifically restricted DOT from issuing tire labeling standards. The Administration still intends to pursue this measure. The 1993 CCAP expected this action to achieve reductions of 1.5 MMTCE in 2000. Current projections for the action are 0.7 MMTCE in 2000 and 4.8 MMTCE in 2010.

Energy Supply Actions

The energy industry is entering an era of unprecedented change due to market and regulatory shifts. The EPAct and actions taken by the Federal Energy Regulatory Commission (FERC) have heightened competition in a variety of energy markets, increasing the efficiency of energy supply. Requirements under the Clean Air Act have prompted a shift to cleaner fuels, such as natural gas. And federal research and development into new energy technologies continues to help the industry increase the efficiency of generating and distributing electricity and meet environmental and market challenges.

The 1993 CCAP includes a number of actions that build on the EPAct, Clean Air, and FERC actions to reduce the amount of CO_2 emitted from energy production and use. The intent is to increase the use of natural gas, encourage the commercial application of renewable-energy resources, make more efficient use of U.S. hydroelectric resources, and reduce the amount of energy lost in electricity transmission.

Among fossil fuels, natural gas emits the least amount of CO_2 per unit of energy provided, and renewable-energy sources (such as solar, wind, geothermal, and biomass energy) emit no CO_2. Nuclear power, which currently provides 22 percent of the electricity generated in the United States, will continue to play a key role in limiting CO_2 emissions from electricity production.

Newer technologies can also increase the efficiency of generating and distributing electricity. Increased efficiency lowers the amount of greenhouse gases emitted by reducing the amount of fuel required to generate and deliver electricity to customers. Action 23 (Increasing Natural Gas Share of Energy Use Through Federal Regulatory Reform) and Action 31 (Transmission Pricing Reform) are not expected to achieve any measurable reductions over baseline energy forecasts.

Climate Challenge *(Foundation Program)*

Through this joint, voluntary effort to reduce, avoid, or sequester greenhouse gases, individual electric utilities are entering into agreements with DOE whereby they are committing to make efficiency improvements in end use, distribution, transmission, and generation; increase their use of energy-efficient electrotechnologies; switch to lower-carbon fuels, such as natural gas, nuclear, or renewable energy; implement transportation actions, including greater use of natural gas-powered and electric vehicles; undertake forestry actions; recover methane from landfills and coal seams; and use fly ash as a Portland cement substitute.

Climate Challenge has 118 Participation Agreements, representing 634 of the over 800 utilities that have expressed interest in the program, and 70 percent of 1990 electricity generation and utility carbon emissions. The utility industry developed nine Climate Challenge initiatives for widespread utility participation. The initiatives include $52 million committed to the Envirotech initiative to accelerate commercialization of renewable-energy technologies; to the Earth Comfort program to increase annual sales of energy-efficient geothermal heat pumps from 40,000 to 400,000; and to the Utility Forest Carbon Management Program, with over $2 million committed to funding several domestic and international forestry projects. Other initiatives include EV America, Tree Power, and the International Donated Equipment Initiative.

The 1993 CCAP did not quantify the impact of Climate Challenge on emissions. DOE estimates that pledged utility actions under the program will result in the reduction of approximately 45.5 MMTCE in the year 2000. The estimate is conservative, in that it does not include reductions not yet quantified, nor the effect of the nine utility industrywide initiatives. Furthermore, it does not include the emission reductions from several utilities that recently joined the program, nor recently increased commitments from existing members. The Administration conducted an analysis of the 45.5 MMTCE of pledged reductions and determined that about 7.6 MMTCE in reductions are beyond any actions included in the 1993 CCAP or in the Administration's Base Case energy forecast, and these reductions in the year 2000 were included as part of the CCAP impacts.

Of the year 2000 reductions for Climate Challenge utilities, about 29 percent (in terms of carbon-equivalent tonnage) are from improvements to existing nuclear power plants; 17 percent from improvements to existing fossil power plants; 17 percent from demand-side energy-efficiency efforts; 8 percent from methane recovery, forestry carbon sequestration, and recycling of coal combustion fly ash; 7 percent from renewable energy; and 22 percent from a broad range of miscellaneous projects, including such areas as improvements to transmission, district heating and cooling, and a range of unspecified activities.

The emission reductions under Climate Challenge will continue to increase as additional utilities join the program, and as existing members add to their existing commitments. Thus, these significant annual reductions are expected to continue well into the next century. Because the Climate Challenge plans do not currently extend beyond 2000, these additional benefits have not been quantified for this analysis. However, given that participation levels are growing, and that most utilities appear to be meeting or expanding upon their commitments, it is reasonable to expect that the Climate Challenge savings would continue at least at the 2000 levels.

Promote Seasonal Gas Use for Control of Nitrogen Oxides *(Action 24)*

Natural gas, an abundant domestic fuel, emits 15 percent less CO_2 per unit of energy provided than oil and 30 percent less than coal. Encouraging the use of natural gas as a pollution control strategy under the Clean Air Act will lower the cost of combating the severe tropospheric ozone pollution problem plaguing many of our cities in a way that also reduces greenhouse gas emissions.

As part of that effort, EPA recently issued guidelines to urge state and local pollution control agencies to allow the use of natural gas in the summer in existing coal- and oil-fired power plants as a strategy to reduce nitrogen oxide (NO_X) emissions. EPA will examine additional regulatory options where shifts to cleaner fuels could provide environmental benefits and cost savings. The 1993 CCAP expected this action to reduce emissions by 2.2 MMTCE in 2000. Current projections are that the program will reduce greenhouse gas emissions by approximately 0.5 MMTCE in 2000. No reductions are expected in 2010 below baseline forecasts.

High-Efficiency Gas Technologies
(Action 25)

The United States will accelerate the commercialization of high-efficiency gas fuel cell technologies, through joint ventures with utilities, research organizations, and technology developers to fund demonstrations and market-entry initiatives. Fuel cells are an ultra-high-efficiency and environmentally benign method of producing electricity and by-product thermal energy. This technology provides a means of converting a fuel's chemical energy into electrical energy without a combustion process.

The 1993 CCAP projected this action would lead to reductions of 0.6 MMTCE in the year 2000. Because funding for this program has been significantly reduced from originally anticipated levels, current projections are that the program will reduce greenhouse gas emissions by 0.1 MMTCE in 2010, with no reductions expected in 2000.

Renewable Energy Commercialization *(Action 26)*

DOE strives to commercialize renewable energy by working with U.S. renewable energy companies, electric utilities, and other end users in cost-shared partnerships that share development risk and advance toward agreed-upon cost-reduction targets. Potential buyers of renewables are encouraged to work directly with the renewables industry and DOE to form market-pull partnership consortia to advance common goals toward accepted commercialization targets. These groups include the Utility PhotoVoltaic Group, Solar II (solar thermal central receiver) Commercialization Consortium, Utility Biomass Energy Commercialization Association, Utility Wind Interest Group, USH_2O (Solar Hot Water) Consortium, and Geothermal Heat Pump Consortium. These buyer-led groups work directly with their respective renewable-energy industry and with DOE cost-sharing at appropriate stages, such as for hardware demonstration projects.

These efforts were expanded under the 1993 CCAP, which expected their combined effect to lead to 2.2 MMTCE of reductions in the year 2000. However, because funding for this program has been significantly reduced from originally anticipated levels, current projections are that the program will reduce greenhouse gas emissions by approximately 0.3 MMTCE in 2000 and 5.6 MMTCE in 2010.

Expanded Utility Integrated Resource Planning (IRP) Assistance *(Action 27)*

In 1994, the expanded IRP program emphasized outreach and education, putting IRP tools in the hands of state and regional regulators, legislators, and utility managers. Core program activities—including an Education Voucher program, an Electric Utility Restructuring Partnership, and an IRP in Public Power Project—exceeded program goals. More than 230 educational vouchers were awarded, and more than thirty seminars were sponsored before Congress discontinued funding the program in fiscal year 1996.

The 1993 CCAP expected this action would reduce emissions by 1.4 MMTCE in 2000. Although the program achieved many of its goals before being terminated, the full emission reduction goals will not be achieved. The reductions that will occur have been accounted for in the baseline energy forecast.

Profitable Hydroelectric Efficiency Upgrades *(Action 28)*

As proposed, this initiative would enable nonfederal developers to invest in environmentally sound upgrades at existing federal hydroelectric projects and to sell the incremental power thus generated at market rates. Significant technological potential exists for increasing generation at hydroelectric facilities, but institutional barriers have complicated efforts to make these profitable efficiency upgrades. Nonfederal investments will increase generation from hydroelectric facilities, reducing the need for fossil-fuel-fired generation. Furthermore, lease payments to the federal government will help reduce the federal deficit. Implementing legislation is currently being drafted.

The 1993 CCAP projected the combined effect of these initiatives would lead to 2.0 MMTCE of reductions in 2000. In the current review, no reductions were attributed to this action due to the uncertainty of enacting implementing legislation.

Energy-Efficient Distribution Transformer Standards *(Action 29)*

In 1992, EPAct required DOE to determine if standards are warranted for distribution transformers. In July 1996 the Oak Ridge National Laboratory prepared a report entitled *Determination Analysis of Energy Conservation Standards for Distribution Transformers*, which was peer reviewed by manufacturers of transformers, steel, and aluminum and by utilities, associations, and energy-conservation public interest groups. The report revealed that all energy-conservation cases that were analyzed are technically feasible, appear to be economically justified, and have the potential for significant energy savings. Based on the energy conservation cases analyzed, the potential savings range from 3.6 to 13.7 cumulative quads over the period 2000–2030. The study methodology consisted of four major elements: development of a data base, development of conservation options, assessments of energy-conservation options, and incorporation of feedback from stakeholders. DOE plans to publish a determination notice this year of its decision as to whether efficiency standards are warranted for distribution transformers.

The 1993 CCAP expected the combined effect of Actions 29 and 30 would reduce emissions by 0.8 MMTCE in 2000. Current projections are that the programs will reduce greenhouse gas emissions by approximately 0.5 MMTCE in 2000 and 1.4 MMTCE in 2010.

ENERGY STAR® Distribution Transformers *(Action 30)*

In 1991, about 7.4 percent of U.S. electric generation was lost while being distributed from power plants to consumers, and approximately 50 billion kilowatt-hours are lost every year in the delivery of electricity from distribution transformers. Stemming transmission and distribution losses will decrease the amount of electricity that needs to be generated to meet electricity demands, thus reducing CO_2 emissions.

The United States is implementing an ENERGY STAR® labeling program to encourage electric utilities to invest in high-efficiency transformers that reduce transformer losses. Participating utilities agree to purchase only qualifying equipment designated with the ENERGY STAR® logo and to accelerate the replacement of higher-loss transformers where economically warranted. EPA is also distributing information regarding energy-efficient transformers to utilities and state regulatory bodies and is helping participating utilities organize group purchases of energy-efficient transformers to obtain lower prices.

The 1993 CCAP expected the combined effect of Actions 29 and 30 would reduce emissions by 0.8 MMTCE in 2000. Current projections are that the programs will reduce greenhouse gas emissions by approximately 0.5 MMTCE in 2000 and 1.4 MMTCE in 2010.

Land-Use Change and Forestry Actions

Trees, plants, and soils absorb and store CO_2 from the atmosphere. In 1995, the annual sequestration by these natural systems (sometimes called carbon "sinks") reduced U.S. net greenhouse gas emissions by 117 MMTCE. When humans affect the biosphere through changes in land use and forest management activities, they alter the natural balance of greenhouse gas emissions.

Most CO_2 emissions occur as the result of burning fossil fuels. Additional CO_2 emissions occur when the carbon stored in the biosphere is released—for example when trees are harvested and logging residual decomposes. Protecting the carbon stored in these forest reservoirs, therefore, can prevent CO_2 emissions from occurring. The United States has already taken significant steps to protect carbon sequestered in forests. Lower harvests in old-growth forests help prevent CO_2 emissions. The shift toward ecosystem management also favors timber harvest methods that inflict less damage, and helps retain carbon on forest lands. Sink protection actions are very cost-effective methods for limiting net CO_2 emissions.

The 1993 CCAP includes several programs to maintain carbon sequestered in forest ecosystems. These programs were projected to provide about 9 percent of the emission reductions needed to reach the greenhouse gas target in 2000, or a total of approximately 10.0 MMTCE in additional annual sequestration. Due to funding cuts of CCAP initiatives, only 0.4 MMTCE in additional annual sequestration is expected by 2000. By 2010, it is anticipated that 2.2 MMTCE will be sequestered annually due to the 1993 CCAP. In addition to Actions 43 and 44, several other actions previously discussed lead to increased carbon sequestration in U.S. forests. In particular, efforts to enhance recycling will limit use of forest products, and Cool Communities' shade tree planting will increase carbon sinks.

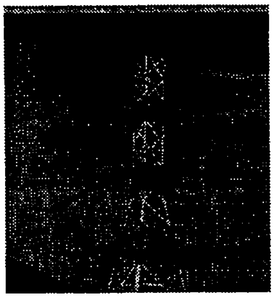
Reduce Depletion of Nonindustrial Private Forests *(Action 43)*

No funding has been provided for this activity beyond the baseline activity that existed prior to the 1993 CCAP.

Accelerate Tree Planting in Nonindustrial Private Forests *(Action 44)*

In cooperation with the state foresters, USDA's Forest Service is working to increase tree planting on poorly stocked and nonstocked nonindustrial private forest land by 94,294 hectares (233,000 acres) within five years. To accomplish this, the federal government will expand technical assistance and reimburse up to 75 percent of the costs of tree planting. Accelerated planting programs increase carbon uptake and could provide significant economic and environmental benefits over the long term.

The 1993 CCAP projected this measure would reduce net emissions by sequestering an additional 0.5 MMTCE in the year 2000. Current projections are that the programs will reduce net emissions by sequestering an additional 0.4 MMTCE in 2000 and 2.2 MMTCE in 2010.



Methane and Other Greenhouse Gas Programs

Although carbon dioxide accounts for the largest share of greenhouse gas emissions in the United States, other greenhouse gases have significantly higher global warming potentials. For example, over a 100-year time horizon, methane is 21 times more effective than CO_2 at trapping heat in the atmosphere, nitrous oxide is 310 times more effective, and HFC-23 is 11,700 times more effective.

Methane

Methane comprised about 11 percent of the U.S. greenhouse gas emissions in 1995. The primary sources of methane emissions in the United States are landfills, domesticated livestock, coal mines, and natural gas systems. The 1993 CCAP includes specific measures for each of these sources.

Methane control options offer tremendous opportunities to reduce greenhouse gas emissions at low cost or even at a profit. In many cases, methane that would otherwise be emitted to the atmosphere can be captured and used to generate power, or can be significantly reduced through the use of cost-effective management methods.

Without the 1993 CCAP, it is currently estimated that methane emissions would increase from 170 MMTCE in 1990 to 175.5 MMTCE in 2000. The 1993 CCAP projected that the combined effects of the methane actions would reduce emissions by 16.3 MMTCE in the year 2000. Current projections are that the actions will reduce greenhouse gas emissions by approximately 15.5 MMTCE in 2000 and 23.4 MMTCE in 2010.

Natural Gas STAR *(Action 32)*

Through EPA's Natural Gas STAR program, natural gas companies are overcoming barriers and adopting cost-effective technologies and practices that reduce emissions of methane. The program was launched in March 1993 with the transmission and distribution sectors and was expanded in March 1995 to include the production sector. To date, the program includes sixty-five corporate partners representing 65 percent of transmission company pipeline miles, 30 percent of distribution company pipeline miles, and 30 percent of U.S. natural gas production.

After becoming a partner, a company submits an implementation plan to EPA and implements the plan over the next three years. In addition to assisting with plan implementation, EPA provides partners with public recognition and works to remove unjustified regulatory barriers.

In 1996, the program reduced methane leakage from natural gas pipelines by over 1.0 MMTCE. The 1993 CCAP expected the expansion of the program would reduce emissions by 3.0 MMTCE in 2000. Current projections are that the expansion of the program will reduce emissions by 3.4 MMTCE in 2000 and by 4.2 MMTCE in 2010. The full Natural Gas STAR program will achieve even larger results.

Landfill Methane Recovery
(Actions 33 and 34)

Landfills are the largest source of anthropogenic methane emissions in the United States. Because methane is a fuel, landfills also represent a tremendous energy resource. The New Source Performance Standards and Emissions Guidelines (Landfill Rule), promulgated under the Clean Air Act in March 1996, require large landfills to capture and combust their landfill gas emissions. Because of the CCAP, this rule was made more stringent, resulting in greater landfill gas recovery.

Through its Landfill Methane Outreach Program, launched in December 1994, EPA is encouraging U.S. landfills to capture and use their landfill gas emissions as a fuel source. This voluntary effort works hand-in-hand with EPA's Landfill Rule to promote cost-effective reductions in methane emissions. By providing reliable technical and economic information about the opportunities to use landfill gas as a fuel, connecting project partners, creating innovative financing opportunities, and demonstrating the many benefits of landfill gas-to-energy, the outreach program is helping landfills affected by the Landfill Rule to achieve the maximum benefit at the lowest cost.

The 1993 CCAP projected the combined effect of the outreach program and the increased stringency of the Landfill Rule would reduce emissions by 5.3 MMTCE in 2000. Current projections are that the programs will reduce emissions by 8.2 MMTCE in 2000 and 12.0 MMTCE in 2010.

Coalbed Methane Outreach Program
(Action 35)

In 1995, methane emissions associated with coal mining operations accounted for approximately 12 percent of U.S. methane emissions. Launched in the spring of 1994, the Coalbed Methane Outreach Program is reducing these emissions by: (1) working with the coal industry and other stakeholders to identify and remove obstacles to increased investment in coalbed methane recovery projects, and (2) raising awareness of opportunities for profitable investments.

Currently, at least thirteen U.S. mines are recovering and using methane. During 1995, at least five new or expanded-use projects were initiated at coal mines. These projects included introducing coalbed methane into the nation's natural gas pipeline supply, generating power from abandoned mine gas, and using methane to replace coal as a fuel source for drying at a coal mine preparation plant.

The 1993 CCAP projected the program would reduce methane emissions by 2.2 MMTCE in 2000. Current projections are that the program will reduce emissions by 2.6 MMTCE in 2000 and by 3.2 MMTCE in 2010.

RD&D for Coal Mine Methane
(Action 36)

In coordination with EPA, the National Mining Association, fuel cell and gas turbine manufacturers, private industry, and others, DOE's Office of Fossil Energy is supporting outreach, cost-shared demonstrations, and market-entry projects to investigate and apply technologies for capturing and using methane emitted during coal mining. A feasibility study was completed and there is broad-based program support for the program. Fourteen proposals were submitted from the private sector in response to the Phase I solicitation for cost-shared projects. Of these, ten were selected and have coal-mine sites committed to methane recovery and use.

The 1993 CCAP projected this action would reduce methane emissions by 1.5 MMTCE in 2000. Funding for this program has been significantly reduced from originally anticipated levels. In the revised analysis, no emission reductions are projected.

RD&D for Landfill Methane *(Action 37)*

This action was terminated due to lack of funding for project demonstrations. However, EPA produced and disseminated technical manuals and expertise as part of its Landfill Methane Outreach Program (Action 34). The 1993 CCAP projected this action would reduce emissions by 1.0 MMTCE in 2000. In the revised analysis, no emission reductions are projected.

AgSTAR Program *(Action 38)*

Through this voluntary pollution-prevention program, EPA and USDA are working with livestock producers to capture the methane released from manure management systems. The captured methane is an on-farm energy resource that can offset energy costs and increase bottom-line profits. Using methane-recovery systems, it is technologically feasible to reduce total U.S. methane emissions from livestock manure by 50 percent. Collateral benefits include reducing surface- and ground-water pollution, odor management, and reducing fertilizer costs.

Launched at the White House Conference on Climate Change in the spring of 1994, AgSTAR currently has more than forty partners, representing over four hundred farms. The program also has more than fifty "allies," representing system and equipment manufacturers, educational institutions, state and local governments, consultants, and others.

The 1993 CCAP projected this action would reduce emissions by 1.5 MMTCE in 2000. Due to funding cuts, delays in initiating model farms, and changes in the industry, current projections are that the program will reduce emissions by 0.3 MMTCE in 2000 and 1.8 MMTCE in 2010.

Ruminant Livestock Efficiency Program *(Action 39)*

This collaborative effort between USDA and EPA reduces methane emissions resulting from the dairy and beef industries, which are responsible for more than 30 MMTCE of methane emissions annually. Methane is produced as part of a ruminant animal's normal digestive process, known as "enteric fermentation." Because the methane produced is actually wasted carbon from the feed, the amount of methane relative to the amount of beef or milk produced is a reliable indicator of the inefficiency of animal production.

This program encourages livestock producers to increase the efficiency of their animals and reduce methane emissions by improving grazing management, providing strategic feed supplementation, improving feed efficiency through the use of production-enhancing agents, improving genetic characteristics and reproduction, and controlling diseases. The program also builds on existing efforts to remove market barriers and to create incentives for increased production of lower-fat milk and meat products.

The 1993 CCAP projected this action would reduce emissions by 1.8 MMTCE in 2000. Current projections are that the program will reduce emissions by 1.0 MMTCE in 2000 and 2.2 MMTCE in 2010.

Nitrous Oxide Programs

Nitrous oxide emissions, mostly from fertilizer and chemical manufacture, accounted for about 3 percent of U.S. greenhouse gas emissions in 1995. Without the 1993 CCAP, nitrous oxide emissions would be expected to increase by about 3 MMTCE from 1990 to 2000.

Improved Fertilizer Management
(Action 17)

A new partnership with American farmers to improve the efficiency of fertilizer management will result in lower emissions of nitrous oxide from soil. This initiative will begin with the conduct of field experiments regarding bacterial denitrification and the testing of management options to improve the efficiency of nitrogen use. Demonstration projects and an outreach campaign using nationwide USDA outlets have been initiated.

The 1993 CCAP projected this action would reduce N_2O emissions by 4.5 MMTCE in 2000. Current projections are that the program will reduce emissions by 5.0 MMTCE in 2000, resulting in a net decrease in emissions between 1990 and 2000 of 2 MMTCE. A reduction of 5.0 MMTCE is projected for 2010.

Other Emission-Reduction Programs

Due to their high global warming potentials, long atmospheric lifetimes, and increasing emissions, hydrofluorocarbons (HFCs) are a growing contributor to the climate change problem. HFCs are also emitted as a by-product of HCFC-22 production (another CFC substitute). Perfluorocarbons (PFCs), emitted primarily during aluminum smelting, are also potent greenhouse gases. In addition, three halogenated substances not included in the 1993 CCAP—SF_6, NF_3, and CHF_3— produce significant greenhouse gas emissions. In 1995, all of the above gases comprised about 2 percent of U.S. greenhouse gas emissions, but emissions are projected to increase as their use as alternatives to ozone-depleting substances increases.

The United States is the first nation to articulate a national strategy to control HFC and PFC emissions. The strategy uses a combination of partnership efforts and regulatory mechanisms to minimize the future contribution of HFCs, PFCs, and halogenated substances to global warming, without disrupting the orderly and cost-effective transition away from CFCs.

Without the 1993 CCAP, emissions of these gases would be projected to grow from 24.4 MMTCE in 1990 to 62.4 MMTCE in 2000. The 1993 CCAP anticipated that the HFC and PFC programs would reduce emissions by 11.8 MMTCE in 2000. Currently, it is estimated that the HFC and PFC actions, including the expansion of Action 40, will reduce emissions from these gases by 20.1 MMTCE in 2000, resulting in total emissions of 42.3 MMTCE in 2000.

Significant New Alternatives Program *(Action 40)*

EPA has used its authority under the Clean Air Act Amendments of 1990 to narrow the scope of uses allowed for HFCs and PFCs with high global warming potentials where better alternatives exist. Emission reductions are being achieved by means of the Significant New Alternatives Program under Section 612 of the amendments. EPA published a final rulemaking in March 1994 that has restricted the use of HFCs and PFCs in a variety of applications. EPA has published four updates to the rule, further extending the emission reductions

The 1993 CCAP projected this action would reduce emissions by 5.0 MMTCE in 2000. Current projections are that the program will reduce emissions by 6.4 MMTCE in 2000 and 23.1 MMTCE in 2010.

HFC-23 Partnerships *(Action 41)*

HFC-23, a potent greenhouse gas, is emitted as a by-product of HCFC-22 production. Through this program, EPA encourages companies to develop and implement technically feasible, cost-effective processing practices or technologies to reduce HFC-23 emissions. Through partnerships with EPA, the entire U.S. HCFC-22 industry has agreed to significantly reduce HFC-23 emission levels by 2000. HCFC-22 producers are developing and implementing processing practices or technologies to reduce HFC-23 emissions where technically feasible and cost-effective. HCFC-22 producers have also completed an assessment of 1990 HFC-23 emissions.

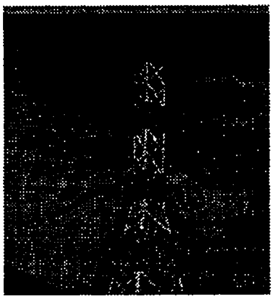
The 1993 CCAP projected this action would reduce emissions by 5.0 MMTCE in 2000. Current projections for 2000 are unchanged, and estimate a sustained reduction of 5.0 MMTCE through 2010.

Voluntary Aluminum Industrial Partnerships *(Action 42)*

Carbon tetrafluoride (CF_4) and carbon hexafluoride (C_2F_6) are emitted as by-products of the primary aluminum production process. Both are potent greenhouse gases, with global warming potentials of approximately 6,500 and 9,200 times that of CO_2, respectively, and lifetimes that exceed 10,000 years.

EPA is partnering with primary aluminum producers to reduce CF_4 and C_2F_6 emissions where technically feasible and cost-effective. Because factors that cause these emissions are a sign of efficiency loss, focus by industry to reduce emissions will result in process enhancements. EPA estimates that emissions of CF_4 and C_2F_6 can be reduced by 30–60 percent industrywide. As of December 1995, twelve companies representing 94 percent of the U.S. primary aluminum production capacity have joined EPA in the Voluntary Aluminum Industrial Partnership.

CCAP projected this action would reduce emissions by 1.8 MMTCE in 2000. Current projections are that the programs will reduce emissions by 2.2 MMTCE in 2000 and 2.4 MMTCE in 2010.



Projections and Effects of Policies and Measures

This section integrates the impact of U.S. climate change policies with revised and extended projections of greenhouse gas emissions and sequestration estimates. It serves as a starting point for a reevaluation of the effectiveness of the 1993 CCAP in meeting the goal of returning net U.S. emissions of greenhouse gases to their 1990 levels by 2000. Analyses of the individual actions (described earlier in this chapter) are integrated with revised forecasts of economic growth, energy prices, program funding, and regulatory developments to provide an updated comprehensive perspective on current and projected greenhouse gas emission levels. For convenience, the revised projections contained here will be referred to as the 1997 *Climate Action Report* (1997 CAR).

Any projection of future emissions, even for a period as short as four years, is subject to considerable uncertainty. Key factors that can increase emissions include more rapid growth in electricity demand, flat rather than slightly rising real energy prices, more rapid economic growth, and further cuts in CCAP funding or effectiveness. Key factors that can reduce emissions include slower growth, increased CCAP program efficacy, greater penetration of baseline energy-efficiency measures, higher energy prices, increased program funding levels, and relatively mild weather in 2000. A qualitative analysis of key uncertainties suggests that net greenhouse emissions in 2000 could exceed their 1990 level by 150–230 MMTCE.

Continued support for research and development efforts in the areas of energy-efficiency and renewable-energy technologies is another key element of the Administration's strategy to implement the 1993 CCAP's vision. These technologies can serve both U.S. economic and environmental interests by reducing costs and emissions, while also providing important export markets for U.S. firms and workers.

The first part of this section describes the current projections of greenhouse gas emissions for the years 2000, 2010, and 2020. It also compares the 1993 CCAP with 1997 CAR projections, the latter of which includes reductions from planned actions. The second part updates the "no action" baseline emission projections data and compares the data to the 1993 CCAP baseline. The last part provides new estimates of the overall impact of the 1993 CCAP that reflect initial implementation experience, changes in the market conditions under which actions operate, and the impact of the shortfall in action funding during recent fiscal years, as well as examines the effect of key uncertainties affecting projected emission levels.

4

Projected Greenhouse Gas Emissions: 1990–2020

Emissions of greenhouse gases are projected to rise at a decreasing rate between now and the year 2020 (Table 4–2 and Figure 4–3). Between 1990 and 2000, emissions increase by 12 percent; between 2000 and 2010, they increase by an additional 11 percent; and between 2010 and 2020, they increase by another 9 percent. The growth of overall greenhouse gas emissions is due to the continued but slowing growth in projected baseline emissions.

Among all gases, net carbon emissions increase the most in absolute terms, while emissions from halogenated gases increase the most in percentage terms. Net carbon emissions are projected to increase by 195 MMTCE between 1990 and 2000, by 137 MMTCE between 2000 and 2010, and 117 MMTCE between 2010 and 2020. The largest percentage increase in net carbon emissions, 16 percent, occurs between 1990 and 2000. (Net carbon emission is equal to gross domestic energy-related carbon emissions, minus international bunker fuel, plus Adjustments to U.S. Energy, plus emissions from Other Sources, minus sequestered carbon.)

Although the projected absolute increase in carbon-equivalent emissions for halogenated gases is relatively small compared to net carbon emissions, halogenated gases increase by 73 percent between 1990 and 2000, by 115 percent between 2000 and 2010, and by 46 percent between 2010 and 2020. The largest absolute increase for these gases was 49 MMTCE, which is projected to occur between 2000 and 2010.

Table 4-2

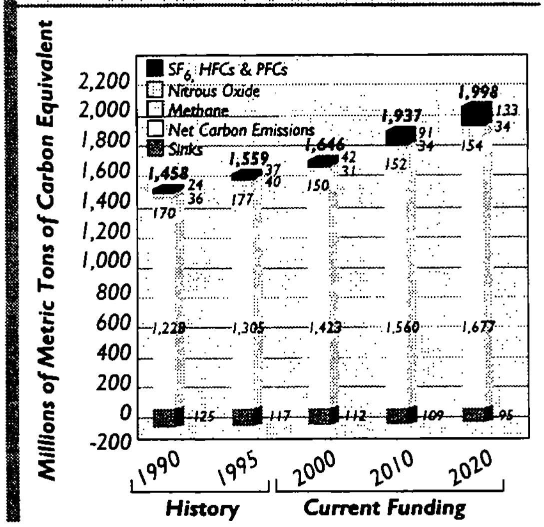
Historical and Projected 1997 CAR Greenhouse Gas Emissions
(MMTCE)

Greenhouse Gas	Historical Emissions		Projected Emissions		
	1990	1995	2000	2010	2020
Net CO_2	**1,228**	**1,305**	**1,423**	**1,560**	**1,677**
Energy	1,327	1,391	1,504	1,634	1,737
Adjustments and Other Sources	26	31	31	35	34
Carbon Sequestration	-125	-117	-112	-109	-95
Methane	**170**	**177**	**150**	**152**	**154**
N_2O	**36**	**40**	**31**	**34**	**34**
HFCs, PFCs and SF_6	**24**	**37**	**42**	**91**	**133**
Total	**1,458**	**1,559**	**1,646**	**1,837**	**1,998**
Difference from 1990		**101**	**188**	**378**	**540**

Note: Projections assume timely receipt of legislative authority for parking cash-out. Program funding is based on funding proportional to current funding with respect to 1993 CCAP funding levels. Columns may not sum due to independent rounding.

Figure 4-3

Historical and Projected Greenhouse Gas Emissions 1990–2020



The results of this integrated analysis combined with a review of actual emission trends to date suggest that CCAP programs can be effective in reducing U.S. greenhouse gas emissions. CCAP actions reduce 4 percent of baseline emissions in 2000, 8 percent in 2010, and 10 percent in 2020. However, despite these substantial contributions, emissions will significantly exceed their 1990 levels in the year 2000.

- U.S. net greenhouse gas emissions in 1990 were 1,458 MMTCE.
- Estimated U.S. greenhouse gas emissions in 1995 were 1,559 MMTCE—6.9 percent above the 1990 level, and somewhat above the short-term increase projected in the first U.S. national communication, the 1994 *Climate Action Report.*
- The updated "point estimate" for greenhouse gas emissions in the year 2000, assuming continued funding support for CCAP actions described in this report, comparable to the 1997 levels approved by Congress is 1,646 MMTCE—188 MMTCE above the 1990 level.
- Under current funding levels, planned actions are estimated to reduce greenhouse gas emissions by 76 MMTCE in the year 2000, compared to what they would have been otherwise (the baseline).
- Due to estimated energy savings initiated by CCAP actions to reduce greenhouse gas emissions, approximately $10.3 billion and $51.1 billion are saved in energy fuel use in 2000 and 2010, respectively.
- If funding were higher, as originally envisioned in the 1993 CCAP, estimated emission reductions would be about 30–40 MMTCE greater.
- While reductions from CCAP programs increase over time, projected greenhouse gas emissions still continue to grow over time, reaching 1,837 MMTCE by 2010 and 1,998 MMTCE by 2020.

The emission projections presented here include the full effect of the "foundation" actions contained in the earlier 1993 CCAP. The three foundation actions scored are: Climate Challenge, Climate Wise Companies, and State and Local Outreach. Emission reduction estimates are sensitive to the order in which foundation actions and other CCAP programs are counted. If reductions resulting from the activities of program participants that can be reflected in other actions or in the baseline are excluded, the estimated "incremental" emission reductions associated with the foundations are estimated to provide emission reductions of 11 MMTCE in 2000, 10 MMTCE in 2010, and 12 MMTCE by 2020. However, the full emission reduction contribution of these programs, which includes all reductions achieved through the activities of program participants, is substantially larger.

Assessing Current Estimates of Greenhouse Gas Emissions

As in the 1993 CCAP, an analytical team was established composed of members from all relevant federal agencies. The team was charged with reevaluating all 1993 CCAP actions and to include new actions as appropriate. A set of inputs was developed so that the modeling effort could be undertaken to account for potential overlap and synergistic effects among actions.

Two modeling scenarios were created: a Baseline scenario and an Action Plan scenario. The Baseline scenario reflects expectations of private- and public-sector behavior based on legislation and federal programs already in effect. The Action Plan scenario combines all the policies contained in the baseline with the actions contained in the 1993 CCAP, as well as new actions developed since the publication of the original CCAP.

The projections contained in this section are derived from a set of specific assumptions about markets, technologies, and resources, such as growth rates in the gross domestic product (GDP) and world oil prices. Four main types of assumptions underlie the projections:

- *Economic factors,* including GDP growth rates, world oil prices, and other macroeconomic assumptions.
- *Energy resources,* including proven reserves and undiscovered resources.
- *Market behavior,* reflecting the demand and supply decisions of energy-market participants, as influenced by energy prices, regulation, and policy programs.
- *Technology factors,* which include information on the costs, performance, and commercial availability of energy-consuming, -converting and -producing technologies.

The Integrated Dynamic Energy Analysis Simulation (IDEAS) model was used as a tool for the integrated analysis of the energy-related actions. Table 4-3 presents a partial list of some of the key factors, containing both input assumptions and model results. This model has elements of both top-down and bottom-up modeling. The macroeconomic effects are combined with microeconomic, technology-specific representations of energy-service methods that link energy supply and demand through equilibrium market prices. Other sectors and gases were estimated independently.

Comparison of 1993 CCAP and 1997 CAR Greenhouse Gas Emissions

A comparison of the 1993 CCAP and the 1997 CAR reveals significant differences between the two sets of projections. These differences are caused by many factors, including the adoption of international accounting standards, the inclusion of newly identified greenhouse gases, updated global warming potential factors used to determine carbon-equivalent emissions, revised estimates of historical emissions, changes in baseline assumptions of emis-

Table 4-3

Major Assumptions and Model Results Underlying 1997 CAR Projections

Factors	1990	2000	2010	2020
Real GDP (billions of 1995 dollars)	6,380	8,005	9,745	11,259
Population (millions)	250	276	299	324
Residential Housing Stock (millions)	94.0	103.0	114.7	125.4
Commercial Floor Space (billion sq. ft.)	64.3	72.3	78.5	85.3
Industrial Production Index	100.0	123.0	151.9	174.0
Energy Intensity (Btu per 1995 dollar GDP)	13,217	12,123	10,767	9,809
Light-Duty Vehicle Miles Traveled (billions)	1,940	2,373	2,885	3,368
Heavy-Duty Vehicle Miles Traveled (billions)	151	181	211	238
New Heavy-Duty-Vehicle on-Road Fuel Efficiency (miles/gallon)	64	6.7	6.7	6.7
New-Car on-Road Fuel Efficiency (miles/gallon)	23.4	25.3	26.9	27.5
New Light-Duty-Truck on-Road Fuel Efficiency (miles/gallon)	17.4	19.0	20.1	21.3
World Oil Price (1995 dollars/barrel)	23.98	18.20	20.33	22.16
Wellhead Natural Gas (1995 dollars/1,000 cubic feet)	1.91	1.85	1.98	2.39
Minemoth Coal (1995 dollars/ton)	23.93	17.96	16.52	15.31
Average Price Electricity (cents/kilowatt-hour)	7.2	6.72	6.38	6.07
Average Price Gasoline (1995 dollars/gallon)	1.28	1.37	1.39	1.43

sions, and revised estimates of the results of emission-reduction actions based on new expectations for program funding and efficacy.

Overall, the estimate for greenhouse gas emissions is now expected to exceed its 1990 value by 188 MMTCE—190 MMTCE more than the difference projected in the earlier 1993 CCAP. Table 4-4 compares the 1993 CCAP estimates to the 1997 CAR estimates on a gas-by-gas basis and summarizes overall differences in the projections. These differences are explained in detail in the following sections focusing on growth in baseline emissions and integrated analysis of the projected growth in emissions.

Baseline Emissions Growth: Review and Update

A critical element of any update of the 1993 CCAP involves reviewing key assumptions used in developing the baseline projections of emissions. This baseline calculation attempts to project the level of greenhouse gas emissions in 2000 absent any 1993 CCAP actions. It necessarily involves critical assumptions about energy prices, economic growth, etc. In the context of this review, several key baseline assumptions have evolved—even in the short period since 1993—in ways that differ significantly from those of in the initial analysis.

Even with no change in the projected funding or effectiveness of actions to limit emissions, an objective of returning emissions in 2000 to their 1990 level can be affected by revisions to 1990 emissions data or changes in the projected "no action" baseline level of emissions in the year 2000. For this reason, developments that affect projected baseline emission levels must be addressed in an updated analysis of a greenhouse gas mitigation strategy.

This section updates the emissions baseline used in the 1993 CCAP analysis. Energy-

Table 4-4

Comparison of 1993 CCAP and 1997 CAR Estimated Projected Greenhouse Gas Emissions
(MMTCE)

Greenhouse Gas	1993 CCAP			1997 CAR			CCAP Gap/ CAR Gap
	1990	2000	CCAP Gap	1990	2000	CAR Gap	
Net CO_2	**1,237**	**1,261**	**24**	**1,228**	**1,423**	**195**	**171**
Energy	1,338	1,379	41	1,327	1,504	177	136
Adjustments & Other Sources	29	29	0	26	31	5	5
Carbon Sequestration	-130	-147	-17	-125	-111	14	31
Methane	**166**	**134**	**-31**	**170**	**150**	**-20**	**11**
N_2O	**39**	**31**	**-8**	**36**	**31**	**-5**	**3**
HFCs, PFCs and SF_6	**20**	**34**	**13**	**24**	**42**	**18**	**5**
Total	**1,462**	**1,459**	**-2**	**1,458**	**1,646**	**188**	**190**

Note: Projections assume timely receipt of legislative authority for parking cash-out. Program funding is based on funding proportional to current funding with respect to 1993 CCAP funding levels. Columns may not sum due to independent rounding.

related and industrial carbon dioxide emissions, other greenhouse gases, and forest carbon sequestration are addressed in separate discussions, each of which includes a review of emission trends through 2000.

The net effects of the updates in baseline greenhouse gas emissions are summarized in Table 4–5 and Figure 4–4. Overall, the increase in baseline greenhouse gas emissions from 1990 to 2000 is 157 million metric tons of carbon equivalent (MMTCE)— an 11 percent increase over the 1993 CCAP growth in baseline emissions. Of the components listed in Table 4-5, the energy-related emissions increase the most in absolute terms—102 MMTCE. However, in percentage terms energy-related carbon emissions increase by less than the overall percentage growth for all greenhouse gases. All greenhouse gases contribute to additional projected growth in baseline emissions.

The current baseline projections are higher than the 1993 CCAP baseline projections for the following reasons:

- Assumptions of energy use in the 1993 CCAP—including lower-than-expected energy prices, the expected mix of economic activity~~,~~ increased electrification, and the technological characteristics of energy-using or -converting equipment—are different from those in the 1997 CAR. Some of these changes are the result of reductions in funding for baseline energy programs that improve energy efficiency, the failure to pass conservation measures included in the President's economic stimulus package, and the removal of federal speed limits. Taken together, changes in domestic energy-related carbon emissions are responsible for an increase of 102 MMTCE in the

Table 4-5

Comparison of 1993 CCAP and 1997 CAR Estimated Historical and Projected Baseline Emissions
(MMTCE)

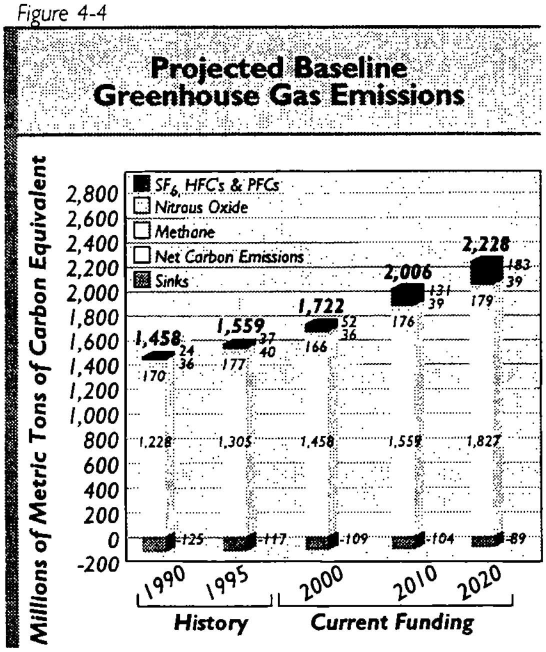
Greenhouse Gas	1993 CCAP			1997 CAR			CCAP Gap/ CAR Gap
	1990	2000	CCAP Gap	1990	2000	CAR Gap	
Total CO_2	**1,237**	**1,337**	**99**	**1,228**	**1,458**	**230**	**130**
Energy	1,338	1,445	107	1,327	1,536	209	102
Adjustments & Other Sources	29	29	0	26	31	5	5
Carbon Sequestration	-130	-137	-7	-125	-109	16	23
Methane	**166**	**150**	**-15**	**170**	**166**	**-4**	**11**
N_20	**39**	**36**	**-4**	**36**	**36**	**0**	**4**
HFCs, PFCs and SF_6	**20**	**45**	**-25**	**24**	**62**	**38**	**13**
Total	**1,462**	**1,568**	**106**	**1,458**	**1,722**	**264**	**157**

Note: The Delta column is computed by subtracting the growth between 1990 and 2000 in the 1997 CAR from the growth between 1990 and 2000 in the 1993 CCAP. Columns may not sum due to independent rounding.

year 2000 over the projection in the 1993 CCAP.

- Congressional appropriations for fiscal years 1996 and 1997 sharply reduced CCAP programs, compared to the levels originally envisioned and requested in the President's budget. If this lower level of funding is maintained through 2000 and if current levels of program efficacy persist, projected emissions will be 30–40 MMTCE higher in the year 2000 than if the CCAP actions were fully funded.
- Changes in assumptions about increased emissions in the categories "Adjustments for U.S. Energy Territories" (includes U.S. Territories and unmetered gas) or "Other Sources" (includes cement production, gas flaring, and other industrial calcination processes) increase projected 2000 emissions by 5 MMTCE.
- Decreasing estimates of projected forest sinks, rather than rising sequestration of carbon in forests, increase projected 2000 emissions by 23 MMTCE over the projection in the 1993 CCAP.
- Higher projected baseline emissions from methane, due in part to revised estimation techniques of agricultural methane emissions, contributed to an increase of 11 MMTCE.
- Higher projected baseline emissions from nitrous oxides increased projected emissions by 4 MMTCE.
- Higher projected baseline emissions of halogenated greenhouse gases, including newly identified gases, increased projected emissions by 13 MMTCE.

Figure 4-4



The Projected Baseline for Carbon Emissions

The current baseline estimate of gross energy-sector carbon emissions in the year 2000 is 1,567 MMTCE, which is 107 MMTCE higher than the year 2000 baseline value used in the 1993 CCAP. Three components are combined to estimate gross energy sector carbon emissions: gross domestic energy-related emissions (for fuel purchased in the United States), subtractions for international bunker fuels, and additions for adjustments for other sources and international territories. By far, the largest change occurred in projected gross domestic energy-related carbon emissions. However, the baseline was also affected by slight revisions to historical emission estimates and revised accounting for fuels used in international transport (international bunkers). The projected change in adjustments for other sources and territories is insignificant (1 MMTCE) and will not be discussed.

The current energy baseline was roughly calibrated to the 1997 *Annual Energy Outlook* (U.S. DOE/EIA 1996a). The primary factors affecting baseline levels of projected energy use and related emissions are the economic and technical assumptions that underlie the projection methodology. Changes in each of these areas since issuance of the original CCAP have caused the projected difference in the growth of energy-related emissions between 1990 and 2000 to be 107 MMTCE higher than projected in the 1993 CCAP.

Changes in Economic Assumptions. As outlined in Table 4–6, the primary reason for the projected increase in carbon emissions between the 1993 CCAP and the 1997 CAR is the change in the projected energy prices. The increase caused by lower projected fossil-fuel prices is aggravated by an increase in expected population growth and disposable income, but is somewhat offset by decreases in expected industrial production growth and commercial floor space, compared to the 1993 CCAP.

Energy Prices. Since the issuance of the 1993 CCAP, most major forecasters of energy prices have significantly revised their expectations of fossil fuel prices downward, especially for natural gas and coal. Projections of fossil energy prices used in developing the updated baseline are significantly lower than those used in 1993—the projected world oil price in 2000 is 13 percent lower, the natural gas wellhead price is 25 percent lower, and the average minemouth price of coal is 30 percent lower. Figure 4–5 compares the original and updated energy price baselines, the latter estimates based on actual energy price data through 1995.

Table 4-6

Comparison of Assumptions: 1990–2000 Annual Growth Rates and Differences

Factors	Annual Growth Rates 1993 CCAP	Annual Growth Rates 1997 CAR	MMTCE Difference
Weighted Average Fossil-Fuel Price	1.6%	-1.1%	39
Electricity Price	0.4%	-0.6%	5
Industrial Production	2.5%	2.1%	-13
Commercial Floor Space	1.3%	1.2%	-3
Population	0.7%	0.9%	1
Disposable Income	1.6%	2.4%	4
Total			**33**

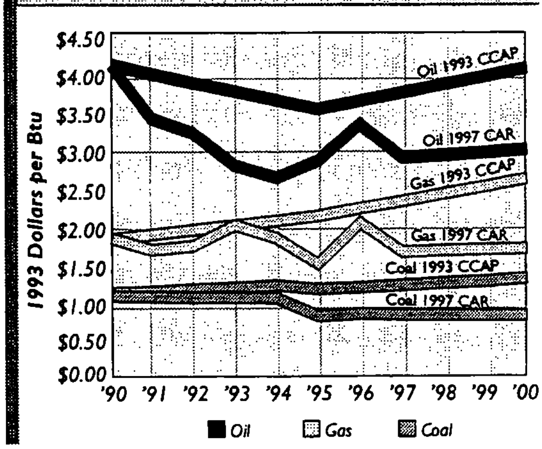
Lower energy price forecasts increase projected energy use and emissions by reducing the incentive for conservation and increased energy efficiency. The switch to a lower price trajectory increases projected baseline energy consumption and carbon emissions by roughly 2.6 percent, or 39 MMTCE.

Electricity Prices. In addition to the decrease in electricity prices caused by the decrease in primary energy prices, the U.S. electric power industry has been undergoing a major restructuring. The move to a more competitive industry has resulted in expectation of lower electricity prices. Although the projections contained in this report do not explicitly attempt to capture completely the move to a competitive electric power industry, the expectation of lower prices, as manifested in the 1997 *Annual Energy Outlook* has been captured. As a result, electricity prices are expected to slightly decrease, in contrast to the increase expected just a few years ago. Based on these revised expectations, projections of baseline gross energy-related carbon emissions are about 5 MMTCE higher in the year 2000. This increase is in addition to the increase projected for the change induced by lower fossil fuel prices.

Industrial Production. Energy-related carbon emissions are sensitive not only to the level of economic activity, which was basically unchanged between the 1993 CCAP and the 1997 CAR, but also to the composition of that activity. The updated baseline incorporates the assumption that a larger share of economic activity will occur in the services sector of the economy and a smaller share will occur in the more energy-intensive manufacturing, agriculture, mining, and construction sectors. As a

Figure 4-5

Primary Energy Prices



consequence, industrial output is now projected to grow at 2.1 percent per year during the 1990s, rather than 2.5 percent as projected in the 1993 CCAP. This change reduces projected emissions by 13 MMTCE.

Other Economic Assumptions. Although relatively minor compared to the change in energy prices or industrial production, expectations for some of the other macroeconomic variables that shape the projections have changed.

- For example, shortly after the 1993 CCAP was published, the U.S. Census Bureau significantly revised its population forecast, assuming higher immigration and birth rates. As a result, more energy is consumed in the residential and transportation sectors—an increase of about 1 MMTCE in the year 2000. The increase is modest because the 1993 CCAP projection of households did not change.
- In another area, disposable income has been rising and is expected to rise more rapidly than assumed just a few years ago, increasing energy use in the transportation sector and, thus, carbon emissions. The change in disposable income is responsible for additional emissions of approximately 4 MMTCE.
- Slightly offsetting these two effects is the decrease in the projected growth of commercial floor space, which was estimated differently from the 1993 CCAP. This decrease results in a reduction of 3 MMTCE in carbon emissions.

The net result of these three changes in economic assumptions is an increase in gross energy-related carbon emissions of about 2 MMTCE in the year 2000.

Changes in Technical Assumptions. Most of the changes in projected energy-related carbon emissions between the 1993 CCAP and the current update are the result of changes in technical assumptions used in the analysis (Table 4-7).

Increased Electrification. In the 1993 CCAP, the Administration baseline projected electricity sales to grow at 1.0 percent a year between 1990 and 2000. The current baseline estimate projects electricity sales to grow faster, at a rate of 2.2 percent per year between 1990 and 2000. For reference, electricity sales grew at 2.2 percent a year between 1990 and 1996, even including electricity-saving actions initiated in the 1993 CCAP. The higher rate of growth in electricity sales results in an increase in carbon emissions of 63 MMTCE. Some of the projected increase in electricity sales is thought to have occurred as a result of a decrease in program funding of energy-efficiency programs. Table 4–8 illustrates the differences in projected

Table 4-7

Impacts of Changes in Technical Assumptions in the Year 2000

Category	MMTCE Difference
Increased Electrification	63
Utility Technology Modifications	5
Feedstocks Carbon Coefficient	- 5
Other Nonelectric Changes	12
Total	**75**

Table 4-8

Changes in Projected Baseline Electricity Growth Rates by Sector: 1990–2000

Sector	History (1990–1996)	1993 CCAP	1997 CAR	MMTCE Difference
Residential	2.7%	1.0%	2.3%	19
Commercial	2.8%	0.0%	2.1%	31
Industrial	1.4%	1.4%	1.9%	13
Total	2.2%	1.0%	2.2%	63

electricity growth rates by sector. The largest sectoral differences between projected electricity sales in the 1993 CCAP baseline and the 1997 CAR baseline occur in the commercial sector (31 MMTCE), followed by the residential (19 MMTCE) and industrial (13 MMTCE) sectors.

Utility Technology Modifications. Two changes made since the 1993 CCAP have increased carbon emissions in the utility sector beyond those accounted for in changes in projected electricity sales: an increase in the assumed heat rate of gas combined-cycle plants and more conservative assumptions regarding the technological characteristics of renewable generating technologies. Although the heat rates of natural gas-fired plants are projected to increase from what they are today by the year 2000, the projected improvement will not be as large as originally envisioned. These two changes are somewhat offset by an assumed improvement in nuclear plant availability, resulting in a net increase in utility sector carbon emissions of approximately 5 MMTCE.

Changes in Carbon Coefficients for Feedstocks. Two changes were made to more accurately account for carbon emissions associated with industrial feedstocks: a decrease in the percentage of carbon sequestered in natural gas feedstocks and a change in the carbon coefficient associated with petroleum feedstocks. Together, these changes accounted for a decrease of about 5 MMTCE in the 1997 CAR compared to the 1993 CCAP.

Other Nonelectric Changes. A number of other changes were made to the assumptions used in the 1993 CCAP to more accurately reflect current energy market conditions. Together, these changes account for an increase in energy-related carbon emissions of 12 MMTCE. An example of such a change is the recently enacted National Highway System bill, which removes current restrictions on state discretion to set speed limits on highways built or maintained with federal funds. This statutory change increases projected transportation sector energy use and emissions due to decreases in fuel economy as average speed increases. A review of state speed limit practices prior to enactment of this restriction and the relationship between fuel economy and speed suggests this legislative action will increase projected emissions in 2000 by 4 MMTCE.

Miscellaneous Policy and Funding Changes. The energy baseline used in the 1993 CCAP assumed adoption of the Administration's economic stimulus package, which was under consideration at the time but was subsequently not adopted by Congress. The package contained many conservation and energy-efficiency measures. The elimination of these programs in the updated baseline raises projected emissions by about 4 MMTCE.

Congressional action on fiscal year 1996 appropriations has also affected the baseline (as well as the effectiveness of actions discussed later in this section). Assuming congressional cuts of ongoing government energy-efficiency programs are continued, carbon emissions will increase by another 7 MMTCE in 2000. A component of this is a reduction in DOE's Weatherization Assistance Program and Federal Energy Management Program, which increase projected emissions in 2000 by 2.5 MMTCE.

Emission Accounting Changes. Subsequent to issuance of the 1993 CCAP, international guidance for consistent reporting of national emission inventories was developed. To maintain consistency with these guidelines, the 1997 CAR excludes emissions resulting from the combustion of international bunker fuels (fuels delivered to marine vessels, including warships and fishing vessels, and aircraft used for international transport). This change reduces estimated carbon emissions in 1990 by 22 MMTCE and projected carbon emissions in 2000 by 27 MMTCE. Because emissions from international bunkers are projected to be larger than the quantity estimated for 1990 historical usage, adoption of the agreed methodology that excludes these emissions reduces the projected growth in emissions by 5 MMTCE relative to the methodology used in the 1993 CCAP.

Projected Baseline for Methane and Other Greenhouse Gas Emissions

Greenhouse gases other than carbon dioxide—such as methane, nitrous oxide, halogenated and perfluorinated compounds (HFCs and PFCs), and sulfur hexaflouride (SF_6)—comprised more than 15 percent of U.S. greenhouse gas emissions in 1990. Important information affecting the baseline emission estimates for these gases has become available since issuance of the original 1993 CCAP.

New projections of HFC emissions have been developed based on more recent information about the production and use of substitutes for chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) being phased out under international obligations to protect the stratospheric ozone layer. This modification, together with a slight revision for 1990 estimated emissions (-3 MMTCE), increase the projected growth in HFC emissions from 1990 to 2000 by about 22 MMTCE.

The inclusion of additional halogenated gases (i.e., SF_6, NF_3, and CHF_3), as well as the identification of nitric acid production as a new source for nitrous oxide, increases baseline growth in greenhouse gas emissions from 1990 to 2000 by about 6 MMTCE.

The IPCC has revised the global warming potentials (GWPs) used to express emissions of other gases in carbon-equivalent terms (Table 4–9). Thus, a fixed amount of emissions of a greenhouse gas other than carbon dioxide is now believed to make either a larger or a smaller contribution to global warming.

The 1993 CCAP had projected noncarbon greenhouse gases to increase by about 6

Table 4-9

Global Warming Potentials (GWPs)

Greenhouse Gas	Old GWPs GWPs	Revised GWPs*
Methane	22	21
N_2O	270	310
CF_4	10,000	6,500
C_2F_6	5,000	9,200
HFC-23	10,000	11,700

* *The GWP values reported here reflect contributions to radiative forcing over 100 years. The IPCC also reports GWPs for 20- and 500-year periods.*

MMTCE in the baseline between 1990 and 2000. The current baseline estimate projects these gases to increase by about 34 MMTCE. Together, these changes are estimated to increase the overall growth in greenhouse gas emissions from 1990 to 2000 by about 28 MMTCE. The revised baselines for methane, nitrous oxides, and HFCs and PFCs follow.

Methane Emissions. The primary U.S. sources of methane emissions are landfills, domesticated livestock, coal mines, and natural gas systems. The baseline forecast for methane has been revised from a decrease of about 15 MMTCE to a decrease of about 4 MMTCE from 1990 to 2000. Most of the changes in baseline projections are due to an increase in some methane sources, particularly agricultural methane emissions. As a result, baseline methane emissions are projected to comprise about 10 percent of U.S. greenhouse gas emissions in the year 2000.

Similar to what was envisioned in the 1993 CCAP baseline, EPA issued a final landfill rule in 1996 that will cut methane emissions in half by 2000. The landfill rule more than offsets expected growth from the other sources. This baseline after the year 2000 is consistent with recent trends in U.S. methane emissions, which have increased by 4 percent over the last five years. During this period, methane emissions from coal mining have fluctuated with changes in production levels at eastern U.S. coal mines, including a major coal strike in 1993. The net result of the change in the baseline assumptions is an increase of about 11 MMTCE for methane emissions in the year 2000 compared to the 1993 CCAP.

Nitrous Oxide Emissions. Baseline N_2O emissions represent about 2.1 percent of U.S. greenhouse gas emissions in the year 2000. Major N_2O sources include nitrogen fertilizer use, automobile combustion, and adipic and nitric acid production. New information about N_2O emissions includes:

- The estimate for N_2O emissions from fertilized soils has been revised downward by about 6 MMTCE for 1990. However, this change does not affect the growth in baseline emissions because emissions from this source are expected to remain fairly constant during the 1990s.
- Nitric acid production is newly recognized as a source of N_2O production. Adding this source increases the 1990 baseline by 3 MMTCE and the 2000 baseline by about 3.5 MMTCE.

N_2O emissions in the baseline are projected to remain at 1990 levels in 2000. Emissions were projected to decrease by 4 MMTCE in the 1993 CCAP. N_2O emissions have increased only slightly over the last five years, although 1994 shows significantly higher emissions from fertilizer use, as farmers planted more acreage and increased fertilizer use to replace nutrients lost in significant flooding that occurred in 1993. In the future, emissions from fertilizer use should return to prior levels, and the results of industrial emission-reduction activities should become apparent.

HFC and PFC Emissions. Hydrofluorocarbons (HFCs) and perfluorinated compounds (PFCs) are emitted in certain industrial applications and are being introduced as alternatives to the ozone-depleting substances phased out under the *Montreal Protocol* and Clean Air Act Amendments of 1990. These gases are projected to represent about 3 percent of U.S. greenhouse gas emissions in the year 2000, but emissions are projected to increase as their use as alternatives to ozone-depleting substances increases. The major source of HFCs is currently a by-product of HCFC-22 production, and the major source of PFCs is currently aluminum smelting.

New information about emissions of HFCs and PFCs since the 1993 CCAP increases the estimated baseline growth of greenhouse gas emissions from 1990 to 2000. The major changes include:

- Emissions from HFCs used as substitutes for CFCs are now expected to grow from negligible levels in 1990 to about 31 MMTCE in 2000, instead of the 23 MMTCE estimated for 2000 in the 1993 CCAP.
- Emissions of HFC-23, a by-product of HCFC-22 production, are expected to grow by about 3 MMTCE between now and 2000 and remain constant after that at about 15 MMTCE. HFC-23 was expected to grow by about 2 MMTCE in the baseline 1993 CCAP.
- PFC emissions from aluminum smelting stay constant at about 5 MMTCE throughout the baseline projection period.
- Significant emissions of three halogenated substances were not included in the 1993 CCAP: SF_6, NF_3, and CHF_3. The primary uses of SF_6 include electric utility transmission systems and magnesium production. In addition, emissions from the semiconductor industry's use of the SF_6, CF_4, and C_2F_6 were not included. These emissions total about 8 MMTCE in 1990 and 12 MMTCE by 2000.
- Higher global warming potentials increase the growth of HFC and PFC emissions in carbon-equivalent terms between 1990 to 2000 by about 2 MMTCE.

The growth in baseline emissions of HFCs and PFCs is beginning now and can be expected to continue through 2000 and beyond.

Projected Baseline for Forest Carbon Sequestration

The new baseline projections by USDA's Forest Service show decreasing annual carbon sequestration in U.S. forests from 1990 to 2000, compared to a slightly increasing sequestration rate in the original 1993 CCAP (see Table 4–4). The change in baseline reflects several developments:

- Estimated net forest growth in the Northeast is declining as the age of hardwood forests is increasing.

- Softwood removals in the South, once well below net growth, now exceed growth in all southern states.
- Reduced harvests in national forests in the West will increase carbon storage, but not enough to offset reduced sequestration in the eastern part of the country.

The latest Forest Service projections indicate a small reduction in total forest land because of continued net losses to nonforest use. While there was a small increase (one percent) in forest land between 1987 and 1992, this trend is expected to reverse because of losses to urban uses and because federal tree-planting programs for private landowners have experienced funding reductions.

- Reduced funding for the Forestry Incentives Program is reflected in the new baseline sequestration estimate for 2000 (125 MMTCE in 1990 and 109 MMTCE in 2000). FIP accounted for about 175,000 acres of tree planting annually in the past.
- The Agricultural Conservation Program was terminated in the 1996 Farm Bill. Active since 1936, in fiscal year 1994 ACP planted more than 12,140 hectares (30,000 acres) of trees. The net effect of reduced funding for FIP and ACP termination is that tree planting under federal programs is likely to decrease by 60,704 hectares (150,000 acres) or more annually. It is unlikely that new private tree planting will offset this impact.
- The Forest Service Stewardship Incentive Program's tree-planting budget has also been cut, lowering baseline carbon sequestration rates by 0.2 MMTCE.

The net effect of changes to the forest carbon sequestration baseline has been to increase greenhouse gas emissions by 23 MMTCE compared to the 1993 CCAP baseline.

Integrated Analysis of Growth in Emissions Between 1990 and 2000

Drawing on the review of individual actions presented in the first part of this chapter, this section presents aggregate emission reductions for the revised 1997 CAR. It then combines these projections of program impacts with the baseline information in that previous section to project emission levels for 2000. To facilitate comparisons, results are reported using the same groupings as in the 1993 CCAP.

As noted in the 1993 CCAP, the aggregate analysis of energy-related actions requires special attention, given the potential for significant interplay among actions, and between actions and the baseline. The updated aggregate action impact projections presented in this section reflect an integrated analysis of energy-related actions developed using the Integrated Dynamic Energy Analysis Simulation (IDEAS) model, the same tool used in the earlier analysis. Because many of the foundation actions include in their announced plans a substantial number of measures that also fall within the broad setting of other actions or baseline assumptions, particular care was taken to avoid double-counting within this analysis.

The sharp reductions from Administration funding requests in appropriations bills enacted by Congress for fiscal year 1996 and 1997 would, especially if continued in future years, have a severe adverse effects on projected greenhouse gas emission levels in 2000 and beyond: (1) reductions in resources available to implement actions significantly diminish projected emission-reduction benefits in 2000 and (2) funding cuts in base renewable research and development and energy-efficiency programs can have potentially large impacts on emissions beyond 2000.

The Administration has consistently requested the funding needed to ensure climate change actions would contribute to U.S. policies to reduce greenhouse gas emissions. However, recent shortfalls in program funding have severely limited the nation's ability to reduce greenhouse gas emissions. A qualitative estimate of this impact suggests that reduced funding is responsible for about a 30–40 MMTCE decrease in overall savings in 2000 that could have been realized if funding were provided in the 1993 CCAP.

The updated "point estimate" of growth in emissions of 188 MMTCE between 1990 and 2000 in the current funding case reflects the combined effect of many changes from the 1993 CCAP, which projected a decrease of 2 MMTCE over the same period. Table 4–10 summarizes the factors contributing to the changing estimate of the emissions gap in the year 2000.

Nonetheless, climate change actions have produced measurable reductions in greenhouse gas emissions and could produce much more in the years to come if current funding levels are maintained. Table 4-11 reports the net reduction of projected actions' performance for the years 2000, 2010, and 2020. The 1993 CCAP performance projections are also provided to facilitate comparisons. The discussion that follows outlines the key forces driving differences

Table 4-10

Changes Between the 1993 CCAP and 1997 CAR for the Year 2000

Greenhouse Gas Category	Higher Baseline	Change in Funding or Effectiveness of Actions*	Total Shortfall
All Greenhouse Gases	**157.3**	**32.6**	**189.9**
Energy Carbon Emissions	101.7	34.4	136.1
Nonenergy Carbon Emissions	5.3	-0.7	4.6
Sinks	23.0	7.2	30.2
Methane	10.7	0.8	11.5
Nitrous Oxides	3.6	-0.8	2.8
HFCs, PFCs, and SF_6	13.0	-8.3	4.7
1993 CCAP Reductions Below 1990 Emissions			**2.4**
Amount Required to Return Emissions to 1990 Levels in the Year 2000			**187.5**

* *The overall reductions in this column would be even larger if foundation actions were not included here as in the 1993 CCAP.*

Table 4-11

Projected Emission Reductions From Climate Change Actions

Sector or Gas	1993 CCAP 2000	1997 CAR 2000	1997 CAR 2010	1997 CAR 2020
Total Energy Related	**66.0**	**31.6**	**94.9**	**144.7**
Commercial	10.6	5.1	24.8	40.7
Residential	16.3	5.2	28.1	37.3
Industrial	19.0	4.8	11.5	16.7
Transportation*	8.1	5.3	15.5	22.1
Supply	10.8	1.3	7.1	19.3
Foundation Actions**	0.0	10.9	9.1	11.9
Methane	**16.3**	**16.0**	**23.4**	**24.2**
HFCs, PFCs, and SF_6	**11.8**	**20.1**	**40.5**	**49.2**
Nitrous Oxides	**4.5**	**5.3**	**5.3**	**5.3**
Forest Sinks	**10.0**	**2.8**	**4.6**	**5.5**
Total Reduction	**108.6**	**76.0**	**169.3**	**229.5**

Note: Totals may not sum due to independent rounding or interactive effects.

* *Assumes receipt of legislative authority for parking cash-out by the end of 1997.*

** *Foundation action partners provide additional reductions in almost all sectors and gases. These values only represent incremental savings not accounted for in other actions or baseline activities. They exclude 0.4 MMTCE for forest sequestration activities accounted for in forest sinks below.*

from the 1993 CCAP analysis for each major greenhouse gas and source category.

Energy-Related Actions

The projected decrease in natural gas prices and increased electricity sales compared to the 1993 CCAP have increased the projected market share for new natural gas-fired electric-generating capacity. Although the reduction in projected natural gas prices is beneficial from a climate change perspective because natural gas is a less carbon-intensive fuel per unit of energy than other fossil fuels and because natural gas technologies tend to be more efficient, it reduces the efficacy of climate change policies designed to reduce electricity use.

Many of the 1993 CCAP actions reduce carbon emissions through their impact on electricity demand. Changes in the marginal fuel used for generation has important implications for translating electricity savings into carbon reductions. Marginal fuel is the fuel consumed to produce the last "unit" of electricity generated. In this instance, the unit is defined as the kilowatt-hour savings from electricity-related actions.

In the original 1993 CCAP, the marginal fuel mix for electricity production was 80 percent coal and 20 percent oil and natural gas in the year 2000. This resulted in carbon emissions decreasing by 0.28 MMTCE for every decrease in 1 billion kilowatt-hours of electricity (0.28 MMTCE/bkWh). In the current estimates, due to an increased market share of natural gas-fired generation, coal accounts for 32 percent and natural gas and oil for the remaining 68 percent of marginal electricity production in the year 2000. As natural gas garners a greater market share of electricity production, the marginal carbon savings per unit of electricity reduced becomes smaller. In the 1997 CAR, the coefficient of reduction decreases from 0.20 MMTCE/bkWh in 2000 to 0.13 MMTCE bkWh by 2020. This change decreases carbon emission reductions by electricity-saving actions by 10 MMTCE in 2000.

Overall, due to funding shortfalls and other factors, carbon emission reductions from energy-related actions have decreased by 34 MMTCE in 2000 compared to the 1993 CCAP. However, after 2000, 1997 CAR-projected reductions are larger than those envisioned in the 1993 CCAP for 2000.

Methane

Overall, carbon-equivalent emission reductions of 16 MMTCE from methane-related actions in 2000 are about the same as the 1993 CCAP.

HFCs and PFCs

Action 40 (Narrowing the use of High GWP Chemicals) is being expanded to form partnerships with newly identified sources described in the beginning of this chapter. Increases in the global warming potentials for HFCs and PFCs have lead to increased effectiveness in Action 42 (Voluntary Aluminum Industrial Partnership Program).

Overall, HFC and PFC reductions are about the same as the 1993 CCAP in 2000. The addition of policies to reduce newly identified gases, such as the Environmental Stewardship Initiative, results in reductions in other gases exceeding the amount claimed in the 1993 CCAP.

Nitrous Oxide

The revised global warming potential for nitrous oxide increases the carbon-equivalent measure of actions taken to reduce nitrous oxide by about 0.8 MMTCE in 2000.

Forest Sinks

Decreases in other federal tree-planting and technical assistance programs for forest landowners increases the potential for participation in this program.

Key Uncertainties Affecting Projected Emissions

Any projection of future emissions, even for a period as short as four years, is subject to considerable uncertainty. Key factors that can increase emissions include more rapid growth in electricity demand, flat rather than slightly rising real energy prices, more rapid economic growth, and further cuts in 1993 CCAP funding or effectiveness. Key factors that can reduce emissions include slower growth, increased CCAP program efficacy, greater penetration of baseline energy-efficiency measures, higher energy prices, increased program funding levels, and relatively mild weather in 2000. A qualitative analysis of key uncertainties suggests that net greenhouse emissions in 2000 could exceed their 1990 level by 150–230 MMTCE.

CCAP Program Funding Levels (+ or -)

The point estimate assumes that CCAP funding through 2000 reflects an extrapolation of fiscal year 1996 funding. Increases or decreases in 1993 CCAP program funding relative to the "current funding" level in fiscal years after 1996 would result in higher or lower levels of projected emissions in 2000.

Required Legislative Authority (-)

Included in the estimates of emission reductions are the assumed adoption of policies that require no additional funding, but require some congressional or regulatory action, such as tire-labeling and energy-efficiency standards. Many of the actions in this category are still assumed to occur, but their deployment has been adjusted to account for delay in their implementation. If legislative authority to initiate these programs is not received, emissions will be higher than projected.

Energy Prices (+ or -)

The relationship between energy prices and emissions is complex. Lower energy prices generally reduce the incentive for energy conservation. However, reductions in the price of natural gas relative to other fuels also encourages fuel switching that can reduce carbon emissions.

The energy price projections from the 1997 *Annual Energy Outlook* used in developing the updated emissions baseline are significantly lower than those used for the 1993 CCAP (U.S. DOE/EIA 1996a). However, real prices for oil and gas are still projected to rise at respective average annual rates of 1.1 percent and 2.5 percent between 1995 and 2000.

The *Annual Energy Outlook* also provides sensitivity scenarios to changes in oil prices. In the year 2000 high oil price scenario, emissions are lower by about 4 MMTCE than projections using the reference-case scenario oil price assumptions. In the year 2000 low oil price scenario, emissions are higher by about 13 MMTCE not using the reference case scenario.

Economic Growth (+ or -)

Higher economic growth increases the demand for energy services, such as vehicle miles of travel, square feet of lighted and ventilated space, and process heat used in industrial production. However, faster growth also reduces the average age of the capital stock, increasing its average energy efficiency. The energy-service demand and energy-efficiency effects of higher growth work in offsetting directions. The effect on service demand is the stronger of the two, so that levels of primary energy use are positively correlated with the size of the economy.

In addition to the reference case used in developing the updated baseline, the *Annual Energy Outlook* provides high and low economic growth cases.

- In the high-growth case, the percentage change increase in energy use is slightly more than half the percentage increase in the size of the economy. By 2000, the high-growth economy is 3.5 percent larger than the reference economy, but energy consumption is only 1.8 percent higher. In addition, carbon emissions are 33 MMTCE larger than the reference case.

- In the low-growth case, a 2.7 percent reduction in the size of the 2000 economy translates into a 1.9 percent reduction in primary energy use. In this case, carbon emissions were 28 MMTCE lower than the reference scenario in the year 2000.

Electricity Demand Growth (+)

While the annual rate of growth in electricity demand from 1995 to 2000 is appreciably higher in the present analysis than in the 1993 CCAP, there is a strong possibility of even faster growth. Regulatory changes to allow competition in wholesale and retail electricity markets could significantly lower prices to electricity end users, while at the same time reduce utility investments in demand-side management and other conservation activities.

If electricity demand grows at 2.1 percent annually (as projected by the Gas Research Institute), rather than by 1.9 percent (as projected in this analysis), carbon emissions will be about 7 MMTCE higher in 2000. The *Annual Energy Outlook* also evaluates a sensitivity that assumes electricity sales to grow at 3.3 percent annually between 1995 and 2000. In that scenario, emissions are 56 MMTCE higher in the year 2000.

Forest Carbon Sequestration (+ or -)

The estimates used here for annual carbon sequestration in U.S. forests include above-ground carbon plus harvested carbon in wood products and landfills. The tree carbon estimates are derived from two independent measurements of forest inventories and growth, and have standard errors of plus or minus 3 percent.

Estimates of other carbon stocks (e.g., forest floor and understory) are likely to be less certain, since there are no comprehensive, statistically valid inventories of nontree organic matter for large areas of the country. USDA estimates their uncertainty at plus or minus 15 percent.

Two other unquantified sources of uncertainty should also be noted. First, since changes in carbon stocks are small compared to the size of the stocks, the level of uncertainty for changes is expected to be higher than that for stocks. Second, estimates projected from historical data using econometric models will be less certain due to the unknown level of uncertainty for the assumptions made in the econometric models. Estimates for all years after 1992 are projected from 1992 data.

Weather (+ or -)

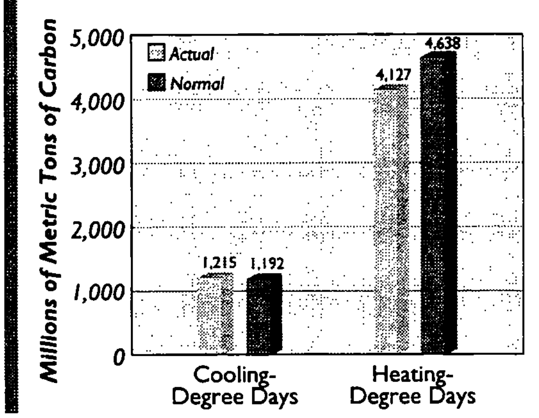
Energy use for heating and cooling is directly responsive to weather variation. The updated baseline assumes thirty-year average values for population-weighted heating- and cooling-degree days. Figure 4–6, which compares average population-weighted heating- and cooling-degree days with actual values for 1990, an unusually mild year, illustrates the importance of interannual weather variation for energy use and emissions. Under average weather conditions, primary energy consumption for heating and cooling in 1990 would have been 1.1 percent higher than its actual value, raising carbon emissions by roughly 16 MMTCE.

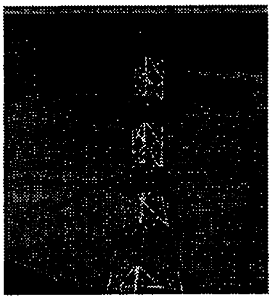
Unlike other sources of uncertainty, for which deviations between assumed and actual trends may become apparent over time, the effect of weather on energy use and emissions in any particular year is revealed only in that year. For the United States, a swing in either direction of the magnitude experienced in 1990 could raise or lower emissions by plus or minus 20 MMTCE relative to a year with average weather. While small relative to total emissions, a change of this magnitude is significant relative to the aim of returning emissions to their 1990 level. Some European countries, which also experienced low levels of energy use and emissions in 1990 due to mild winter weather, have opted to compare 1990 and 2000 emissions levels on a "climate-adjusted" basis in their first national communications.

Figure 4-6

Actual and Normalized Net Heating- and Cooling-Degree Days for 1990

In a normal year, CO_2 emissions would have been 1,339.3 MMTs. In 1990, they were 1,322.5 MMTs, or 1.25 percent lower.





Joint Implementation

Cooperative efforts between countries or entities within them to reduce net greenhouse gas emissions offer significant potential to combat the threat of climate change and to promote sustainable development. Such "joint implementation" can achieve greater emission reductions than may otherwise be likely if each country pursued only domestic actions. It may also achieve these reductions more cost-effectively on a global basis. Joint implementation offers additional benefits, including:

- promoting technology cooperation with developing and transition economies;
- encouraging private-sector investment in developing economies and disseminating technologies that reduce greenhouse gas emissions;
- providing local health, environmental, and economic benefits in host countries; and
- testing and evaluating methods to measure, track, and verify emission reduction costs and benefits.

The concept of joint implementation was formally adopted in Article 4(2)(a) of the United Nations Framework Convention on Climate Change, which provides for Parties to the Convention to meet their obligation to reduce greenhouse gas emissions "jointly with other parties." In 1993, the United States announced a pilot joint implementation program, the U.S. Initiative on Joint Implementation (USIJI), as part of the U.S. *Climate Change Action Plan*. The USIJI program supports the development and implementation of voluntary projects, between U.S. and non-U.S. partners, that reduce, avoid, or sequester greenhouse gas emissions. Final ground rules for the USIJI program, published in the *Federal Register* in June 1994, describe the purpose of the pilot program, outline the time line for evaluation and reassessment of the program, define eligibility criteria for domestic and non-U.S. participants, establish an Evaluation Panel to review potential USIJI projects, and define criteria for acceptance of projects into the USIJI portfolio.

USIJI is the first and currently most developed joint implementation pilot program worldwide. To date, the program has received over sixty project proposals, resulting in twenty-five accepted projects in eleven countries. These projects apply a variety of technologies and practices, including wind, geothermal, hydroelectric, and solar energy; coal to natural gas fuel switching, methane gas capture; and sustainable forest management and preservation.

Projects accepted into the USIJI program are evaluated against the nine criteria, and the four other areas of consideration, included in the USIJI Groundrules. These criteria are intended to identify projects that support the development goals of the host country while providing greenhouse gas benefits beyond those that would occur in the absence of the joint implementation activity. The criteria have been formulated to ensure that projects accepted into the program will produce real, measurable net emission reductions, which will be measured, monitored, verified, and reported.

The USIJI program is directed by an Interagency Working Group, chaired by the Department of State, which has the primary responsibility for policy development. The USIJI Evaluation Panel is co-chaired by the Environmental Protection Agency and the Department of Energy, and includes representatives from the Agency for International Development and the Departments of Agriculture, Commerce, Interior, State, and Treasury. The USIJI Secretariat, an interagency staff, supports the day-to-day operation of the USIJI program. Technical experts are drawn from a wide variety of organizations to assist the Secretariat in the proposal review process and to provide technical assistance to project developers.

Sample Joint Implementation Projects

Czech Republic—Decin Fuel Switching, Cogeneration, and Efficiency Improvements Project

The City of Decin in the Czech Republic is supplying both heat and potable hot water to local apartment blocks. This project has converted Decin's Bynov district heating plant from coal to natural gas. A cogeneration facility also has been built to provide steam and electricity. USIJI partners include the City of Decin, Center for Clean Air Policy, Wisconsin Electric Power Company, Commonwealth Edition Company, and NIPSCO Development Company.

Russian Federation—RUSAFOR Afforestation Project

This project has planted seedlings on 506 hectares (1,250 acres) of marginal agricultural and burned forest land, will sequester greenhouse gas emissions, prevent soil erosion, and foster public participation in joint implementation activities. USIJI partners include the International Forestry Institute, Oregon State University, Russian Federal Forest Service, Sustainable Development Technology Corp., and the U.S. Environmental Protection Agency.

Costa Rica—Río Bravo Project

This project has two components: the purchase of land to add to existing protected areas and the implementation of sustainable forest management practices on the larger conservation area to produce economic benefits to the neighboring population. USIJI partners include CINergy, Detroit Edition Company, PacifiCorp, Programme for Belize, The Nature Conservancy, Utilitree, and Wisconsin Electric Power Company.

Costa Rica—Plantas Eólicas S.A. Wind Facility

This 20-megawatt wind electric plant will displace electricity currently generated by the burning of fossil fuels. USIJI partners include Charter Oak Energy, Inc., Merrill International, Ltd., and Plantas Eólicas, S.A.

The USIJI Secretariat offers a variety of technical services to support both the development and the implementation of USIJI projects:

- *Technical Assistance*—The USIJI Secretariat has assembled a team of technical experts to assist project partners in calculating emission reduction benefits, developing monitoring and verification plans, and identifying sources of project financing. Technical assistance can take the form of on-site consultations, technical guidance materials, and workshops and training seminars.
- *Capacity Building*—The USIJI Secretariat supports human and institutional capacity building in key countries, including co-sponsoring workshops, conducting training, providing project-specific technical assistance, and supporting the development of national joint implementation programs and offices.
- *Information Resources*—The USIJI Secretariat maintains a resource center that includes technical guidance documents, data bases, a fax-on-demand service, an information hotline, and an Internet site.
- *Public Recognition*—The USIJI Secretariat helps project participants increase the visibility of their participation in the program, including showcasing individual projects in international publications, conferences, and workshops; highlighting projects in the USIJI *International Partnership Reports*; and sponsoring awards and public recognition events.

The USIJI Secretariat will accept project proposals at any time and will provide limited technical assistance to project developers to help address USIJI project evaluation criteria and other considerations as specified in the USIJI Groundrules. A formal proposal evaluation and acceptance process is conducted three times a year.