

Climate Action Report*

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

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Introduction and Overview

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 $\frac{1}{4}$ 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 already been proposed (and are included in this report), an effort to develop a comprehensive program to address rising U.S. greenhouse gas emissions is being developed in the context of the ongoing treaty negotiations 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 $\frac{1}{4}$. 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 (CO₂); methane (CH₄); nitrous oxide (N₂O); the chlorofluorocarbons (CFCs) and their substitutes, including hydrofluorocarbons (HFCs); the long-lived fully fluorinated hydrocarbons, such as perfluorocarbons (PFCs); and ozone (O₃). 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 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.

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 1.8-6.3°F)).
- The average global 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.

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. The increasing role of trade in the U.S. economy 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 (CO₂), methane (CH₄), and nitrous oxide (N₂O). 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 CO₂ emissions by about 8 percent. During 1990–95, greenhouse gas emissions continued to rise in the United States, with CO₂ increasing approximately 6 percent, methane approximately 4 percent, N₂O nearly 10 percent, and HFCs approximately 7 percent. Fossil fuel combustion accounts for 99 percent of total U.S. CO₂ 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 CO₂ emissions, methane's footprint is large: in a 100-year time span it is considered to be twenty-one times more effective than CO₂ 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 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.

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 ₂ O)	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.

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 188 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 230 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 Parties. 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.

Table 1-2

Summary of Actions to Reduce Greenhouse Gas Emissions

(Million Metric Tons of Carbon Equivalent)

Action Number	Action Title	1993 Action Plan Estimate		Revised Estimate*		
		2000	2000	2005	2010	2020
	Residential & Commercial Sector Actions	26.9	10.3	29.4	53.0	78.4
1	Rebuild America	2.0	1.6	3.0	6.3	7.1
1 and 2	Expanded Green Lights and Energy Star Buildings	3.6	3.4	8.5	16.3	30.2
3	State Revolving Fund for Public Buildings	1.1		Terminated		
4	Cost-Shared Demonstrations of Emerging Technologies					
5	Operation and Maintenance Training for Commercial Building Facility managers and Operators ^{3.8}	0.0	0.5	1.0	1.0	
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					
9	Cool Communities	4.4	0.6	1.9	4.3	7.7
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					
20	Innovative Transportation Strategies	6.6	4.6	8.4	10.9	17.0
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	Not quantified		
	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	Not quantified			
	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	Improve Efficiency of Fertilizer Nitrogen Use***	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, NICE³, and USDA's Expansion of Recycling Technology. Energy savings and sequestration are scored separately.

*** Energy savings and N₂O savings are scored separately.

+ 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.

Vulnerability and Adaptation

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 CO₂ concentrations would inundate 10,000 square kilometers (3,900 square miles) of dry land and 8,000 square kilometers (3,120 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 fluctuations 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 an impressive 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 and sequestration strategies (e.g., through the Global Environment Facility (GEF)). Bilateral and multilateral opportunities are currently being implemented, 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 agencies working in the climate change field, including the Environmental Protection Agency, the National Oceanic and Atmospheric Administration, 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 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 supporting the preparation of national climate action plans for eighteen developing 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 $\frac{1}{4}$ may work great changes, and accomplish great affairs among mankind, if [one] first forms a good plan $\frac{1}{4}$ [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.

National Circumstances

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.

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 summertime 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.

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).

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)		Percent of Total Land Area
	Hectares	Acres	
Forests	262	576.4	28.6
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.			
Pasture and Range	239	525.8	26.1
Permanent grassland and other nonforested pasture and range.			
Cropland	186	409.2	20.3
All land in the crop rotation, including land used for crops, land left idle, and land used for pasture.			
Special Uses	114	250.8	12.4
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.			
Other Uses	114	250.8	12.5
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.			
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

Forests

Forest land offers a significant sink for greenhouse gases but may also be highly vulnerable 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 could allow the land to recover if restoration efforts are made.

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 CO₂ 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 studies. Experimental results suggest that the direct effects of a doubling of atmospheric CO₂ (the CO₂ "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.

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.

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 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 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 5.4 percent in 1996, 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 CO₂ emissions.

The increasing role of international trade in the U.S. economy 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. 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, to the extent not offset by efficiency gains, 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 2-4). 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 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 2-5 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. 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 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.

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.

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 2-6). 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 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 legislative 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 2-7). 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 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 2-8).

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 emissions. 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 2-9). 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 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.
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- 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.

“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.

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 responsibility 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.

Greenhouse gas inventory

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. emission sources related to energy consumption, forest sinks, and some CH₄ 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 (CO₂), methane (CH₄), nitrous oxide (N₂O), and ozone (O₃). 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 CO₂, CH₄, and N₂O 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.

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
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 ₂ O)	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

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

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. 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 CO₂ emissions from fossil fuel consumption had the greatest impact during the five-year period. In most cases, emissions from methane, N₂O, HFCs, PFCs, and sulfur hexafluoride (SF₆) have remained relatively constant or have increased slightly. For example, methane emissions increased by just over 4 percent. The rise in HFC, PFC, and SF₆ 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 SF₆, 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 CO₂ 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.

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. N₂O 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 SF₆ 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.

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 policymakers to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to other gases. CO₂ 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:

$$\text{MMTCE} = (\text{MMT of GHG } x)(\text{GWP of GHG } x)(12/44)$$

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 CO₂ 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 SO₂ 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 ₂ F ₆	9,200
C ₄ F ₁₀	7,000
C ₆ F 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 CO₂ 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 CO₂ have risen about 30 percent, principally because of fossil fuel combustion, which accounts for 99 percent of total U.S. CO₂ emissions (Seki and Christ 1995). Changes in land-use and forestry activities can emit CO₂ (e.g., through conversion of forest land to agricultural or urban use) and can act as a sink for--or absorb--CO₂ (e.g., through improved forest management activities).

Table 3-2 summarizes U.S. sources and sinks of CO₂, while the remainder of this section discusses CO₂ 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.

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.

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.

Overall, emissions from fossil fuel consumption increased during the five-year period. While emissions of CO₂ 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, CO₂ 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 CO₂ 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 CO₂ 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. CO₂ 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 CO₂ 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. CO₂ emissions (Figure 3-5).

The type of energy electric utilities consume directly affects the volume of CO₂ emitted. For example, some of this electricity is generated with low-emitting technologies, 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 CO₂ 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 CO₂. In 1995, flaring activities emitted approximately 2 MMTCE, or about 0.1 percent of total U.S. CO₂ 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 CO₂, in the long run, their emissions do not increase total atmospheric CO₂ 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.

CO₂ 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. CO₂ 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. CO₂ 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 CO₂.

The production processes that emit CO₂ include cement production, lime production, soda ash production and use, limestone consumption (e.g., in iron and steel making), and CO₂ manufacture. In 1995, CO₂ 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. CO₂ emissions. Since 1990, emissions from cement, lime, and CO₂ 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, CO₂ is created when calcium carbonate (CaCO₃) is heated in a cement kiln to form lime and CO₂. This lime combines with other materials to produce clinker, while the CO₂ 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-CaCO₃) in a kiln, creating calcium oxide (quicklime) and CO₂, 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 CO₂ is generated as a by-product. In addition, CO₂ 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 CO₂ 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)

CO₂ 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 CO₂ 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 CO₂. 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 CO₂ 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 CO₂ 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 (CH₄) is an integral component of the greenhouse effect, second only to CO₂ 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 CO₂ 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, CO₂, 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.

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.

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 CO₂, methane,

carbon monoxide, nitrous oxide, and oxides of nitrogen. Field burning is not considered to be a net source of CO₂ emissions because the CO₂ 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 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 N₂O. As the number of catalytic converter-equipped vehicles has risen in the U.S. motor vehicle fleet, so have emissions of N₂O from this source (DOE/EIA 1993b).

In 1995, N₂O emissions from mobile sources totaled 9.2 MMTCE (or 23 percent of total N₂O emissions), and total N₂O 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. N₂O 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 N₂O, or 13 percent of total U.S. N₂O emissions. By 1996, all adipic acid production plants in the United States are expected to have N₂O 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 N₂O 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 N₂O is formed and emitted to the atmosphere. In 1995, about 3.6 MMTCE of N₂O were emitted from nitric acid production, accounting for 9 percent of total U.S. N₂O emissions.

Other Sources of N₂O

Other N₂O-emitting activities include the burning of agricultural crop residues and changes in land use. In 1995 agricultural burning contributed approximately 0.01 MMTCE of N₂O 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 N₂O 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 SF₆ 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 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.

Table 3-5

1995 Emissions of HFCs, PFCs, and SF₆

HFCs, PFCs, and SF₆ are powerful greenhouse gases. In addition to having high global warming potentials, SF₆ 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 ₂ F ₆	0.00057	10,000	9,200	1.42
C ₄ F ₁₀	0.00001	2,600	7,000	0.02
C ₆ F 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 C₆F₁₄.

From 1990 to 1993, U.S. emissions of HFCs and PFCs remained relatively constant, while SF₆ 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 (CF₄ and C₂F₆) are emitted during aluminum smelting.

Sulfur hexafluoride (SF₆) is the most potent greenhouse gas the IPCC has ever evaluated. About 80 percent of the worldwide use of SF₆ is as an insulator in electrical transmission and distribution systems. SF₆ 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 SF₆ emissions, approximately 8 MMTCE.

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

Emissions of Criteria Pollutants

In the United States, carbon monoxide (CO), nitrogen oxides (NO_x), nonmethane volatile organic compounds (NMVOCs), and sulfur dioxide (SO₂) are commonly referred to as “criteria pollutants.” CO is produced when carbon-containing fuels are burned incompletely. Oxides of nitrogen (NO and NO₂) 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 SO₂ 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 SO₂), criteria pollutants are regulated under the 1970 Clean Air Act and its successive amendments. These gases also affect 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, SO₂ emitted into the atmosphere affects the Earth’s radiative budget negatively; therefore, it is discussed separately from the other criteria pollutants in this section.

Sources and Effects of Sulfur Dioxide

Emitted into the atmosphere through natural and human processes, SO₂ affects the Earth’s radiative budget through photochemical transformation into sulfate particles that (1) scatter sunlight back to

space, thereby reducing the solar 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 SO₂ emissions on radiative forcing is likely negative (IPCC 1996), although the distribution of the influence is not uniform.

SO₂ is also a major contributor to the mix of urban air pollution, and can significantly increase acute and chronic respiratory diseases. Once SO₂ 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 SO₂ emissions in the Clean Air Act of 1970 and its subsequent 1990 amendments.

Electric utilities are the largest source of SO₂ emissions in the United States, accounting for about 66 percent of total SO₂ emissions in 1995. Coal combustion contributes approximately 96 percent of those emissions. SO₂ 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 SO₂ emissions (U.S. EPA/OAQPS 1996).

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 CO₂. 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 SO₂
(Millions of Metric Tons)

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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

Mitigating Climate Change

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 and 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 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:

Preserving the Environment--The 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 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).

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 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 54,000 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.
-

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 additional actions for inclusion in the 1993 CCAP update. Comments were also received during a public hearing on September 22, 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.

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 used to comply with 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 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 revised CCAP is projected to achieve reductions of about 169 MMTCE in the year 2010 and about 230 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); 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.

Action Plan Funding
(Millions of Dollars)

* Agency	FY 1995		FY 1996		FY 1997		FY 1998
* Agency	Presi- dent's Request	Appropri- ation	Presi- dent's Request	Appropri- -ation	Presi- dent's Request	Appropri- ation	President's Request
Depart- ment of Energy	\$208	\$37	\$185	\$69	\$144	\$69	\$109
Environ- mental Protectio n Agency	123	102	138	83	142	86	149
Others	13	9	13	6	19	8	8
Total	\$344	\$184	\$336	\$158	\$305	\$163	\$266

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 0.1 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 through 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 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 (CO₂) 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 CO₂ 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 CO₂ 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 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 3.4 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 0.6 MMTCE in 2000 and 4.3 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 "MECcheck" 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 EPart 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. CO₂ 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 CCAP establishes working partnerships with U.S. industry to help improve energy efficiency and productivity.

The 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 1.8 MMT in 2000 and 3.7 MMT 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. NICE³ 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 CO₂ 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 CO₂ 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 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 CO₂ 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 CO₂ per unit of energy provided, and renewable-energy sources (such as solar, wind, geothermal, and biomass energy) emit no CO₂. Nuclear power, which currently provides 22 percent of the electricity generated in the United States, will continue to play a key role in limiting CO₂ 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 CO₂ 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, USH₂O (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 CO₂ 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 CO₂ 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 CO₂ emissions occur as the result of burning fossil fuels. Additional CO₂ 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 CO₂ 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 CO₂ 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 CO₂ emissions.

The 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 CO₂ at trapping heat in the atmosphere, nitrous oxide is 310 times more effective, and HFC-23 is 11,700 times more effective.

Methane Programs

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 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 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 is expected to 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 CCAP, nitrous oxide emissions would be expected to increase by about 3 MMTCE from 1990 to 2000.

Improve Efficiency of Fertilizer Nitrogen Use (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 N₂O 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--SF₆, NF₃, and CHF₃-- 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 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 (CF₄) and carbon hexafluoride (C₂F₆) 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 CO₂, respectively, and lifetimes that exceed 10,000 years.

EPA is partnering with primary aluminum producers to reduce CF₄ and C₂F₆ 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 CF₄ and C₂F₆ 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 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 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.

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, although small in absolute terms, 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	2005	2010	2020
Net CO₂	1,228	1,305	1,423	1,490	1,560	1,677
Energy	1,327	1,391	1,504	1,567	1,634	1,737
Adjustments and Other Sources	26	31	31	33	35	35
Carbon Sequestration	-125	-117	-112	110	-109	-95
Methane	170	177	150	152	152	154
N₂O	36	40	31	32	34	34
HFCs, PFCs and SF₆	24	37	42	69	91	133
Total	1,458	1,559	1,646	1,742	1,837	1,998
Difference from 1990		101	188	284	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.

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

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)	6.4	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)	7.20	6.70	6.40	6.10
Average Price Gasoline (1995 dollars/gallon)	1.28	1.37	1.39	1.43

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-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.

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 CO₂	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	-112	13	30
Methane	166	134	-31	170	150	-20	12
N₂O	39	31	-8	36	31	-5	3
HFCs, PFCs and SF₆	20	33	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.

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 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 12 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.

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 CO₂	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
N₂O	39	36	-4	36	36	0	4
HFCs, PFCs	20	45	-25	24	62	38	13

and SF₆

Total	1,462	1,568	106	1,458	1,722	264	157
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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.

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.

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 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).

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

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 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.

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

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 hexafluoride (SF₆)--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 7 MMTCE.

The inclusion of additional halogenated gases (i.e., SF₆, NF₃, and CHF₃), 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.

Table 4-9

Greenhouse Gas	Global Warming Potentials (GWPs)*	
	Old GWPs	Revised GWPs*
Methane	22	21
N ₂ O	270	310
CF ₄	10,000	6,500
C ₂ F 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.

The 1993 CCAP had projected noncarbon greenhouse gases to increase by about 6 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 N₂O emissions represent about 2.1 percent of U.S. greenhouse gas emissions in the year 2000. Major N₂O sources include nitrogen fertilizer use, automobile combustion, and adipic and nitric acid production. New information about N₂O emissions includes:

- The estimate for N₂O 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 N₂O production. Adding this source increases the 1990 baseline by 3 MMTCE and the 2000 baseline by about 3.5 MMTCE.

N₂O 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. N₂O 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: SF₆, NF₃, and CHF₃. The primary uses of SF₆ include electric utility transmission systems and magnesium production. In addition, emissions from the semiconductor industry's use of the SF₆, CF₄, and C₂F₆ 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.

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.

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

Table 4-11

Sector or Gas	Projected Emission Reductions From Climate Change Actions*			
	1993 CCAP 2000	2000	1997 CAR 2010	2020
Total Energy Related	66.0	31.6	94.9	144.6
Commercial	10.6	5.1	24.9	41.1
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	7.0	18.9
Foundation Actions**	0.0	10.9	9.1	11.9
Methane	16.3	15.5	23.4	24.2
HFCs, PFCs, and SF₆	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.

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 led 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. The reported forest estimates do not include sequestration in the forest floor understory complex.

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 non-tree

organic matter for large areas of the United States. USDA estimates their uncertainty at plus or minus 15 percent.

Additional unquantified sources of uncertainty should also be noted. First, deriving annual stock change estimates from standing stock estimates would increase uncertainty further. Second, estimates projected from historical data using econometric models will be less certain due to the unknown uncertainty of the assumptions made in the econometric models. Estimates for all years after 1992 are projected from 1992 data. Additionally, certain lands have not been included in these stock estimates.

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.

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 Edison 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--Rio 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 Edison Company, PacifiCorp, Programme for Belize, The Nature Conservancy, Utilitree, and Wisconsin Electric Power Company.

Costa Rica--Plantas Eolicas 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 Eolicas, 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.

Table 4-12

Place and Title of Activity	Summary of AIJ Projects Reported Under Annex F*				
	Type of Project	Stage of Activity ¹	Project Life ²	Greenhouse Gases ³	
				CO ₂ (MTs)	Other (MTs)
Belize					
Rio Bravo Carbon Sequestration Pilot Project	Forestry/Land Use- -Forest management and conservation	In progress	40 yrs.	4,770,000	
BEL/MAYA Biomass Power Generation Project	Renewable Energy- -Biomass	Mutually agreed	30 yrs.	3,500,000	4,800 NO _x
Bolivia					
Noel Kempff M. Climate Action Project	Forestry/Land Use- -Forest management	In progress	30 yrs.	53,170,000	
Costa Rica					
Plantas Eolicas, S.A., Wind Facility	Renewable Energy- -Wind; fuel switching	In progress	15 yrs.	263,000	
ECOLAND: Esquinas National Park	Forestry/Land Use- -Forest management and conservation	In progress	15 yrs.	1,267,000	
KLINKIFIX: Klinki Forestry Project	Forestry/Land Use- -Forest management	Mutually agreed	40 yrs.	6,970,000	
Project CARFIX: Sustainable Forest Management	Land Use	In progress	25 yrs.	21,780,000	
Tierras Morenas Windfarm Project	Renewable Energy- -Wind	In progress	15 yrs.	187,000	
Aeroenergia Wind Facility Project	Renewable Energy- -Wind	In progress	20 yrs.	36,000	
BIODIVERSIFIX: Forest Restoration	Forestry/Land Use- -Tropical forest management and reforestation; wood	In progress	50 yrs.	18,500,000	
Dona Julia Hydroelectric Project	Renewable Energy- -Hydropower	In progress	15 yrs.	210,000	
Czech Republic					
Fuel Switching and Cogeneration for Decin District	Energy Use	In progress	25 yrs.	605,000	

Heating System					
Ecuador					
Forest Conservation Bilsa Reserve	Forestry/Land Use-- -Forest management and conservation	In progress	25 yrs.	1,600,00 0	
Honduras					
Bio-Gen Biomass Power-Generating Project Phase 1, Guaimaca Site Phase 2, Sava Site	Renewable Energy-- -Biomass	Mutually agreed	Over 20 yrs.	2,300,00 0	
Solar-Based Rural Electrification in Honduras	Energy Use	Mutually agreed	20 yrs.	17,000	
Indonesia					
Reduced-Impact Logging in Kalimantan	Forestry/Land Use-- -Forest management; wood	Mutually agreed	40 yrs.	207,000	
Mexico					
Scolet Te-- Sustainable Land Management and Carbon Sequestration Halophyte Cultivation in Sonora	Multicomponent Forestry	In progress	30 yrs.	843,000	
	Renewable Energy-- -Biomass	In progress	Soil carbon storage, over 10 yrs.	2,400	
Nicaragua					
El Hoyo Monte Galan Geothermal Project	Renewable Energy-- -Geothermal	Mutually agreed	35 yrs.	19,770,0 00	
Panama					
Commercial Reforestation of Chiriqui Province	Forestry/Land Use-- -Reforestation	Mutually agreed	25 yrs.	213,000	
Russian Federation					
District Heating Improvements in Zelenograd	Energy Efficiency-- Industrial/HVAC	Mutually agreed	30 yrs.	1,613,00 0	
RUSAFOR: Saratov Afforestation Project	Forestry/Land Use-- -Afforestation	In progress	60 yrs.	128,000	
RUSAGAS: Fugitive Gas Capture Project	Energy Efficiency-- Fossil fuels; natural gas; energy intensity	Mutually agreed	25 yrs.		1,220,000 tons CH ₄
Reforestation in Vologda	Forestry/Land Use-- -Reforestation	Mutually agreed	60 yrs.	880,000	

Uniform Reporting Format:
National Program on Activities Implemented Jointly Under the Pilot Phase

I. Designated national authority for activities implemented jointly

Name (English): U.S. Initiative on Joint Implementation
Acronym: USIJI
Street: 1000 Independence Avenue, S.W.
Code: PO-6
City: Washington, D.C. 20585
Country: U.S.A.
Telephone: (202) 586-3288
Fax: (202) 586-3485, -3486
E-mail: csmt@igc.apc.org
Contact Person: Dr. Robert K. Dixon, Director
Direct Telephone: (202) 586-3003
Direct Fax: (202) 586-3485, -3486
Direct e-mail: rdixon@igc.apc.org

II. Description of program structure and features

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

III. Process for obtaining approval

A. Briefly describe the procedure:

The USIJI Secretariat manages the proposal evaluation process. The evaluation schedule includes announcements of newly accepted USIJI projects in June 1997, October 1997, and February 1998. After project developers submit project proposals to the USIJI Secretariat, they are assigned to Proposal Managers on the USIJI Secretariat staff, who screen them for completeness. Project developers are contacted for additional information, clarification, and/or consultation, as necessary. Proposals are then distributed to technical reviewers for a thorough evaluation. Each proposal is reviewed by a team of experts familiar with the technology, country-specific issues, and environmental effects specific to that proposal.

Following technical review, Proposal Managers draft a Decision Memorandum for each proposal. Each Decision Memorandum includes discussion of how well each USIJI criterion is addressed by the proposal and a recommendation for acceptance or rejection by the Evaluation Panel. The Panel meets to review the recommendations present in the Decision Memoranda. Project developers are then notified in writing whether their project has been accepted by the USIJI Evaluation Panel. Project proposals that meet most, but not all, of the USIJI criteria are placed in an "in-development" category. In-development proposals are eligible to receive technical assistance and, once all USIJI criteria are met, may be reevaluated at a subsequent USIJI Evaluation Panel meeting.

Project proposals may be informally submitted to the USIJI Secretariat at any time for feedback from Secretariat staff. Once a proposal has been formally submitted to the USIJI Secretariat within proposal submission deadlines, the Secretariat will make every effort to complete the evaluation process within 90 days.

B. List all criteria for national acceptance of an activity implemented jointly:

- a. Criteria that support decision 5/CP.1:
 - 1. Is acceptable to the government of the host country.
 - 2. Involves specific measures to reduce or sequester greenhouse gas emissions initiated as a result of the USJI program, or in reasonable anticipation thereof.
 - 3. Will reduce or sequester greenhouse gas emissions beyond those referred to in 3. a. above and, if federally funded, is or will be undertaken with funds in excess of those available for such activities in fiscal year 1993.
 - 4. Identifies associated environmental and developmental benefits and impacts.
- b. Other criteria for national acceptance of AIJ:
 - 1. Provides data and methodological information sufficient to establish a baseline of current and future greenhouse gas emissions:
 - in the absence of the specific measures of the project or
 - as a result of the specific measures of the project.
 - 2. Contains adequate provisions for tracking the greenhouse gas emissions reduced or sequestered as a result of the project and, on a periodic basis, for modifying such estimates and for comparing actual results with those originally projected.
 - 3. Contains adequate provisions for external verification of the greenhouse gas emissions reduced or sequestered by the project.
 - 4. Provides adequate assurance that greenhouse gas emissions reduced or sequestered over time will not be lost or reversed.
 - 5. Provides for annual reports to the Evaluation Panel on the emissions reduced or sequestered, and on the share of such emissions attributed to each of the participants—domestic and foreign—pursuant to the terms of voluntary agreements among participants.

4. Summary of activities

A. Summarize AIJ projects reported under Annex 1 (see Table 4–12).

B. Summarize non-AIJ activities.

Conferences/Workshops

- January 1995: JI Southeast Asia Regional Workshop, Bangkok, Thailand.
- March 1995: JI Central and Eastern Europe Workshop, Prague, Czech Republic.
- March 1995: JI South American Regional Workshop, Santiago, Chile.
- May 1995: Middle East Regional Workshop, Abu Dhabi, United Arab Emirates.
- May 1995: USJI Program Conference, Arlington, Virginia, USA.
- June 1995: JI Workshop for the Americas, San Jose, Costa Rica.
- June 1996: Sponsored the regional Southeast Asia Workshop on AIJ in Jakarta, Indonesia.
- November 1996: Co-sponsored the JI Capacity Building Workshop in La Paz, Bolivia.
- January 1997: Co-sponsored the conference on AIJ: Developing Country Perspectives in New Delhi, India.
- April 1997: Co-sponsored the JI Capacity Building Workshop in Santiago, Chile.

Guidance Documents and Other Materials

- April 1996: U.S. submitted Report on AIJ to the UN FCCC Secretariat.
- March 1997: In conjunction with the IIEC, published and distributed a brochure and report: Opportunity Knocks: The Export Market for Energy Efficiency and Renewable Energy Products and Services.
- Published and distributed a USJI Program Brochure, 6 editions of International Partnerships Reports, 2 USJI Fact Sheets, a USJI poster, and 4 sample USJI proposals.
- Established a USJI page on the Internet, JI Online, which can be accessed at <http://www.ji.org>
- Published a draft resource document: USJI Project and Proposal Development.

Vulnerability and Adaptation

The Earth's climate has warmed about 0.5°C (0.8°F) over the last century, and is expected to warm another 1.0-3.5°C (1.8-6.3°F) over the next century under "business as usual" scenarios. Though present actions under the Framework Convention on Climate Change (FCCC) will have some effect on future greenhouse gas emissions and the magnitude and rate of additional climate change, significant climate change will occur and will have important consequences for society (IPCC/WMO/UNEP 1996b).

- *Human health* will be compromised by increases in the rate of heat-related mortality and in the potential for the spread of both vector-borne diseases (such as malaria, dengue, yellow fever, and encephalitis) and nonvector-borne diseases (such as cholera and salmonellosis).
- *Food security* will be threatened, especially in the tropics and subtropics, where many of the world's poorest people live.
- *Water resources* will be increasingly stressed, leading to substantial economic, social, and environmental costs, especially in regions that are already water-limited and where there is strong competition among users.
- *Human habitat* will be lost where small islands and coastal plain and river areas are particularly vulnerable to sea level rise.
- *Natural ecosystems* will be degraded as their composition, geographic distribution, and productivity shift along with the responses of individual species to changes in climate. This may lead to reductions in biological diversity and in the goods and services society derives from ecosystems

The overall impact of climate change on any single region or sector will depend on the rate and magnitude of change and the vulnerability or sensitivity of the region's natural and human systems to such change. Given these complexities, society and nature may have to simultaneously adapt to rising sea levels, more variable precipitation patterns and temperature extremes, changes in water supplies, disruption of ecosystems, and changes in many other climate-sensitive natural resources. This chapter briefly describes the U.S. efforts to evaluate vulnerability to climate change and to identify key measures that may reduce its risks.

Enhancing the Adaptability of Natural Systems

Various U.S. planning, regulatory, and policymaking organizations that deal with existing environmental issues have many years of experience and technical expertise in managing natural resources. As the United States explores options to enhance its adaptability to climate change, it must seek solutions that both manage existing pressures and enhance its flexibility to respond to future climate change issues. Such solutions include enhanced contingency planning, ecosystem management, and scientific research and development.

Contingency Planning

Most human institutions and infrastructure assume that the past is a reasonable surrogate for the future. For example, engineers designing reservoirs and other coastal structures use the statistical term "stationarity" to reflect their belief that historical rainfall patterns and coastal processes are reliable indicators of future patterns. And farmers know that inclement weather may destroy their crops, but based on historical averages, expect their crops will succeed in most years.

Climate change poses problems for these approaches to resource management. For example, rainfall is increasing worldwide, and extreme rainfall events (more than 5 centimeters, or 2 inches, a day) have increased about 10 percent over the last century in the United States. Delaying anticipatory measures may leave the United States unprepared for the changes that do occur and may increase the possibility of impacts that are irreversible or that substantially increase the cost of adaptation.

Human adaptation to climate change is distinct from biological adaptation. It can include any means of adjustment to altered conditions, such as biological, technical, institutional, regulatory, behavioral, or economic adjustments. Adaptation can be grouped into three broad categories:

- *passive adjustments*--e.g., gradual changes in human behavior and tastes, or biologically driven changes in communities);
- *deliberate reactive responses*--e.g., management responses; and
- *anticipatory actions*--e.g., planning, engineering, or regulatory responses taken in advance of observed climate change.

Contingency planning minimizes the social, environmental, and economic costs of natural disasters or accidents by addressing immediate natural resource management needs and by increasing the resiliency of those resources to floods, forest fires, droughts, and hurricanes. New anticipatory approaches include developing mitigation strategies based on rigorous identification and assessment of an area's or an ecosystem's vulnerability to climate change and drawing on a wide range of expertise.

For example, following the Great Midwest Flood of 1993, the Scientific Assessment and Strategy Team was assembled from more than a dozen federal agencies. This multidisciplinary team of experts recommended a new approach--managing the Mississippi River Basin floodplain as a system rather than as a patchwork of individual components. The team also recommended returning some agricultural areas to wetlands and improving floodplain management by using more advanced maps and other scientific and technical information.

Similarly, in February 1997 the U.S. Department of Agriculture, the Federal Emergency Management Agency, the Department of the Interior, the Small Business Administration, and the Western Governors Association agreed to a series of measures to systematically address the threat of drought. They formed a Western Coordinating Council and a federal interagency coordinating group to work on drought mitigation, response, and policy, including improved planning, communication, and data management efforts.

Ecosystem Management

An ecosystem is defined as "the combination of organisms living in a region and the physical and chemical environment that they inhabit." Ecosystems themselves do not "adapt" and respond to climate change as a unit; rather, the coexisting ecosystem species may do so.

The Costs of Natural Disasters

New anticipatory approaches are needed to increase the resilience of vulnerable areas to and improve their recovery from future natural hazards. Since 1992, more than fifteen U.S. weather-related disasters have caused several hundred deaths. Total costs from floods, heat waves, hurricanes, blizzards, and hail storms (including the West Coast winter storms of December 1996-January 1997) are in the range of \$90 billion. For example:

- Hurricane Hugo cost the federal government about \$1.6 billion.
- Hurricanes Andrew in 1992 and Fran in 1996 caused billions of dollars in damage, and substantial federal disaster payments.
- Damages from the Mississippi River flooding in 1993 are in the range of \$10–20 billion.

Some organisms are more tolerant than others to extremes of climate and environmental variability. How well species respond to climate extremes in rainfall and temperature may be a measure of how well they may adapt and be able to withstand future changes without undergoing local or total extinction. Ecosystems are thus subject to disruption by changing climate, as their individual species migrate in response to changing habitats and environments.

Ecosystem Management Task Force

The goal of ecosystem management is to maintain and restore the health of ecological resources affected by pollution, urbanization, changing climate, and other stresses. One of the most far-reaching environmental recommendations of the Clinton Administration's National Performance Review of the federal government was to develop a "proactive approach to ensuring a sustainable economy and a sustainable environment through ecosystem management." This recommendation catalyzed movement toward more holistic approaches to environmental protection and resource conservation efforts.

An interagency Ecosystem Management Task Force was established in 1993, consisting of Assistant Secretaries from twelve federal departments and agencies, as well as representatives from several White House offices, to promote adoption of the ecosystem approach to environmental management. The task force identified both barriers and opportunities that federal agencies face in implementing the ecosystem approach. It selected seven ecosystems as case studies: parts of the Great Lakes, the coastal Louisiana wetlands, the South Florida ecosystem, the southern Appalachian highlands, Pacific Northwest forests, Prince William Sound, and the Anacostia River watershed in metropolitan Washington, D.C. These initiatives have spurred similar efforts for other critical ecosystems stressed by climate change and human activities.

National Environmental Monitoring and Research Initiative

The ecosystem approach is a major paradigm shift. Traditionally, federal agencies have

responded to their mandates by dealing with single resources, single stresses, and single issues. However, many environmental issues, including climate change, are best considered in a more integrated context. Building the knowledge base and assembling the information to support a more integrated approach is a critical priority.

The National Environmental Monitoring and Research Initiative was launched to address this need by improving the efficiency, effectiveness, comprehensiveness, and coordination of federal environmental monitoring and research networks and programs. Better integration of scientific data produced from the nation's extensive remote-sensing, inventory, survey, monitoring, and research networks will allow the simultaneous assessment of multiple resources and will contribute to a better understanding of the causes and effects of environmental change. This ability to predict how an action will affect the future health of ecosystems will allow significant advances from our current management of ecosystems and natural resources.

Working through the National Science and Technology Council's Committee on Environment and Natural Resources, the federal government is developing a national framework for an integrated monitoring and research network. By allowing comprehensive evaluation of our nation's environmental resources and its ecological systems, this national network will produce a sound scientific information base to support natural resource assessment and decision making.

Several federal partners are participating in this venture: the Departments of Agriculture, Energy, and the Interior; the Environmental Protection Agency; the National Aeronautics and Space Administration; the National Oceanic and Atmospheric Administration; and the National Science Foundation. This activity will achieve closer linkage of federal environmental monitoring and research networks and programs, which together account for \$650 million in annual expenditures. An important result will be provision of information to the public on what it is getting in return for its annual investment of over \$120 billion in pollution abatement and control.

Work on the National Environmental Monitoring and Research Initiative is well under way:

- A draft framework for integration has been completed and published.
- A Mid-Atlantic Regional Workshop in April 1996 laid the foundation for a pilot demonstration project beginning in 1997.
- A National Workshop in September 1996 (including representatives from state and local government, industry, nongovernmental organizations, and academic experts) endorsed the draft framework and was charged by the Vice President to develop a Report Card on the Health of the Nation's Ecosystems by 2001.
- An interagency Environmental Monitoring Steering Committee is coordinating program development and implementation, working closely with the Federal Geographic Data

Committee, the Interagency Task Force on Monitoring of Water Quality, and other relevant organizations.

This initiative is a partnership with state and local governments, nongovernmental organizations, private industry, and citizens--the people whose decisions affect the nation's environment. Coordinating this nationwide effort with those of other nations, and with the major global observation programs that are now being defined and implemented, can lead to an international monitoring network capable of detecting large-scale, long-term environmental changes, such as improved responses to environmental policies or detection of changes due to climate and to other environmental or anthropogenic influences.

Research and Development

Given the current inability of experts to accurately predict the regional timing, magnitude, and consequences of change, decision makers must plan for natural and managed systems in the face of considerable uncertainty. A wide variety of anticipatory measures can be still be taken, including a broad and comprehensive research agenda to develop the understanding of the climate system needed for effective decision making on climate change issues.

In addition to a wide variety of research spanning the physical and socioeconomic sciences, extensive interdisciplinary research efforts are necessary for addressing the complex interactions of chemical, biological, ecological, and social processes that affect the climate system. In response to this need for objective information, the United States has created and sustains the U.S. Global Change Research Program, which organizes and coordinates the activities of many different federal agencies. Since its initiation in 1988, the Research Program has focused on understanding the physical climate system and projecting future global changes. (See chapter 6 for more information about the Research Program.)

As scientific understanding of the climate system has advanced, new areas of research have emerged. These include the impacts of climate change--that is, the changes in ecological and socioeconomic sectors resulting from climate change, the regional implications of such changes, how species are likely to adapt to them, and the adaptation strategies that may be useful in managing natural resources as climate changes. Promising research areas include regional-scale modeling, integrated assessment, ecosystem science, climate variability, GAP analysis for design of migration corridors, and genetic engineering of crops.

These research activities have relevance beyond climate change for managing natural resources, and in some cases have been undertaken for reasons other than climate change concerns. Yet even when they are outside the formal mechanism of the U.S. Global Change Research Program, they are providing, with little or no modification, useful information and results.

Over the past decade, a series of global environmental changes has been documented in increasing detail, including climate change, loss of biodiversity, stratospheric ozone depletion, alteration of the land surface, and changes in the nitrogen balance of the Earth's soils and waters. That human activities are among the driving sources of such changes has been established beyond reasonable doubt.

Increased regional-level understanding of environmental change is needed to better explain how these phenomena affect both each other and ecosystems and to design effective mitigation and adaptation measures. Achieving this enhanced understanding is a priority for the U.S. Global Change Research Program, which is incorporating the following approaches in its long-term research strategy.

Regionally Resolved Estimates of the Timing and Magnitude of Climate Change

The Earth is a complex system, with physical, chemical, and biological processes interacting on a wide range of temporal and spatial scales. Because direct experiments involving these complex interactions and feedbacks (which would yield reliable predictions of future climates) are impossible, scientists must depend on simplified predictive models of the climate system. To be more useful for work on the ecological and socioeconomic consequences of climate change, the resolution of such models must be improved by an order of magnitude, so that they can simulate natural phenomena on scales of tens, rather than hundreds, of kilometers.

Regional Analyses of the Consequences of Climate Change Alone and in the Context of Other Pressures on Ecosystems

Properties of ecosystems that humans value--such as plant productivity, carbon-storage capacity, and species composition--may change in response to climate change. The Vegetation-Ecosystem Modeling and Analysis Project clearly indicates that concurrent changes in climate and in atmospheric concentrations of carbon dioxide could alter an ecosystem's structure substantially by causing shifts, expansions, and/or contractions of forests, grasslands, and other major plant ecosystems. However, many of the detailed impacts of climate change remain uncertain.

Improving predictions will require the study of complex interactions among ecological processes through long-term monitoring activities, large-scale field manipulations, and simulation modeling efforts. As an initial step, the U.S. Global Change Research Program is sponsoring a series of workshops during 1997-98 on regional vulnerabilities to climate change. These workshops will form the basis for a national assessment of climate change impacts, which will be completed in 1999.

Integrated Assessment Methods

Climate change decision making must be supported with careful analyses of causes and effects that bring together the physical, biological, economic, and social sciences. Forecasts of greenhouse gases and atmospheric aerosols, which are integral to climate analyses, must consider the forces of economics and technology that drive and control emissions. In turn, assessments of possible ecological and social impacts, and the analyses of alternative strategies for adaptation and mitigation, need to be based on careful climate science that takes into account its own uncertainties. The continued refinement of integrated assessment tools, such as coupled-model frameworks that include complex, nonmarket, societal decisions, holds considerable promise for enhancing the analyses of climate change and its impacts.

Assessing Vulnerabilities and Identifying Adaptation Strategies

Managed systems (e.g., coastal zones and range lands) are more adaptable to climate change than "lightly managed" or natural ecosystems (e.g., parks and undeveloped land) (IPCC/WMO/UNEP 1996b). For example, agriculture and water resources are vulnerable to climate change but can become highly adaptable by crop improvement and

development, water conservation and desalination, and a variety of other strategies.

Natural ecosystems respond slowly and may be unable to migrate as their ideal climate range shifts north or to higher elevations. Fragmentation of the landscape (from urbanization) may also inhibit migration. The gaps in our understanding of how these natural systems are maintained or how they change make realistic response strategies difficult to identify today.

The United States is analyzing the vulnerabilities of key sectors to climate change-- notably, agricultural land, water supplies, coastal areas, forests, lightly managed ecosystems, and human health. At the same time, it is developing strategies to facilitate the adaptation of these resources and systems to a changed climate. In many cases, this may involve modifying existing natural resource management strategies originally designed to cope with other environmental stresses, such as air pollution, population growth, and changes in land use.

The degree of modification needed will vary by sector. In some cases, the additional suite of stresses brought about by climate change could significantly weaken already highly stressed and fragile systems, while other systems may be more robust. In all cases, contingency planning, ecosystem management techniques, and research and development are desirable to increase resiliency and minimize the negative consequences of climate change. The strategies described in the following sections form a national aggregate of adaptation options for vulnerable sectors.

Agricultural Land

Agriculture in the United States is an intensively managed, market-based activity. Throughout the world, agriculture has adapted continuously to climate variability as it has adapted to changes in economic conditions. The American agricultural sector continues to respond to new technologies, new environmental regulations, and changes in population and market demands. Market forces are a principal catalyst for rewarding and encouraging rapid adaptation, and the domestic agricultural sector is preparing to adapt to climate change.

Vulnerability

The potential effects of climate change on agriculture are difficult to predict. Agricultural productivity is likely to be affected worldwide, which would lead to alterations in both national and multinational regions, redistributing agricultural activities and changing farming intensity. In the United States, the range over which major crops are planted could eventually shift hundreds of miles to the north. In addition to temperature shifts, the availability of fresh water and the distribution of pests and diseases may have significant impacts on production.

For American farmers, who are already facing increasingly competitive and growing world markets, any relative change in regional productivity compared with the rest of the

world would signal market-driven incentives to adapt to the changes. Some individual farmers may benefit through locally improved yields or higher prices, while others may suffer because of relatively severe local climate changes requiring significant economic investment to adjust farming systems. Rapid geographical shifts in the agricultural land base, brought about by very rapid climate changes, could disrupt rural communities and associated infrastructures.

Adaptation Strategies

Climate change adds a new dimension to government efforts to improve the knowledge and skills of farmers, to encourage adoption of new technologies, and to expand the array of options available to farmers. Efforts to maintain the genetic diversity of crops and improve farm technologies will help to ensure sufficient production for an increasing population in an uncertain climate. Similarly, efforts to speed the rate at which appropriate farming systems can be adopted lower the potentially high financial and human costs of adjusting to climate change.

The past performance of the research community in developing new ways for certain crops to overcome climatic constraints suggests its substantial capacity to respond in the future. For example, through the efforts of crop breeders and agronomists, the hard red winter wheat zone has been greatly expanded since 1920 as the varieties of the crop have been effectively adapted to colder and warmer temperatures and drier conditions. The steady improvements in productivity have also been made possible by improved farm-management practices.

More recently, biotechnological methods, including new tissue-culturing and genetic-engineering tools, combined with traditional agricultural breeding methods are allowing scientists to alter plants to incorporate greater disease, insect, and weed resistance and to better withstand environmental stresses, such as cold, drought, and frost. Such precision agricultural techniques should help tailor crops to prevailing regional conditions as the climate changes.

The opportunities for adjusting to climate change are numerous. However, oversubscribed water demands in the Great Plains and the West will limit the potential for compensating adjustments. The inability to predict changes at regional and local levels makes effective response difficult to project, as does a lack of experience and knowledge about alternative crops and agricultural practices suitable for rapid adaptation to such changes.

Recent changes in U.S. agricultural policy have decoupled support payments from maintaining production of a particular crop. As a result, producers will rely more heavily on market signals and can adapt more readily to the environmental changes. Crop insurance may become increasingly costly under a harsher climate and, if not well designed, may tend to diminish the incentive for farmers to take appropriate precautionary actions to reduce their exposure to climate risks. In contrast, water-resource planning and changes in state and regional laws regarding the marketing of conserved water are already

enhancing incentives for efficiently using water resources in agriculture.

The most pressing tasks that the federal government is currently undertaking with regard to agriculture and climate change are:

- Developing a nationwide telecommunications system to improve the transfer of technology and information to farmers to speed adaptation and innovation activities.
- Strengthening research, development, and pilot programs for computerized decision aids and farm- and ranch-management systems.
- Supporting research and technology that will ensure that the agricultural sector can deal successfully with the various challenges of the next century, through the continuing development of new crop varieties to meet the needs of farmers due to changes in soil water, pest, climate, and processor requirements.

New Farm Bill and Carbon Sinks. The Federal Agricultural Improvement and Reform Act of 1996 has significantly changed U.S. agricultural policy. Under the 1996 Farm Bill, farmers continue to have an opportunity to enroll their environmentally sensitive land in the Conservation Reserve Program 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 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 Conservation Reserve Program, with cost-share assistance in the three Forestry, Stewardship, and Environmental Quality Incentives Programs. Tree planting under cost-share programs has averaged about 136,364 hectares (300,000 acres) a year, but is expected to decline in future years in response to lower levels of federal funding.

Research Programs. A wide range of U.S. agricultural research programs can support adaptation to climate change. Ongoing programs include the development of stress-tolerant crop varieties, strengthening of the plant germ plasm repositories and long-term germ plasm storage, the plant genome mapping program, and biological engineering research in pest resistance.

Extensive resources are being devoted to addressing how elevated atmospheric CO₂ concentrations may directly influence crop physiology, growth, yield, and water use and how elevated CO₂ levels may interact with other environmental factors and management practices. Many agricultural practices, like tillage, fertilization, and the burning of crop residue, greatly influence fluxes of greenhouse gases such as CO₂, methane, and nitrous oxide; research is being conducted to examine how climate change may alter these processes.

The U.S. Global Change Research Program is conducting research on developing management tools for responding to the potentially undesirable effects of climate change on agricultural productivity domestically and worldwide. These tools include methods for aggregating plant-scale models to predict regional-scale effects. Current research programs also focus on the needs of production systems, long- and short-term storage and

post-harvest protection systems, food safety and quality, processing technologies, transportation technologies, and market systems.

Coastal Zones and Fisheries

The Intergovernmental Panel on Climate Change (IPCC) has concluded that global sea level has risen 10-25 centimeters (about 4-10 inches) during the past century and may rise a minimum of 15-95 centimeters (about 6-38 inches) by 2100, with a best estimate of 50 centimeters (20 inches) by the year 2100.

Vulnerability

The U.S. coastal zone includes thousands of square miles of undeveloped coastal wetlands, developed barrier islands, and dry mainland areas, within 1 meter (about 3 feet) of mean high water. Accelerated population growth along U.S. coasts is increasing stress on coastal systems and placing them at greater risk from potential climate change.

Rising sea level inundates low-lying areas, erodes shores, exacerbates coastal flooding, and increases the salinity of rivers, bays, and aquifers. Some areas are already experiencing rapid erosion due to such factors as subsidence, storms and hurricanes, coastal processes influenced by local geology, sediment supply, tidal range, ocean currents, weather extremes, rising relative sea level, and human-induced land-use changes. Coastal wetlands, for example, are already eroding, particularly in Louisiana and Maryland. These wetlands provide habitat for numerous species of birds, are a nursery ground for many commercial fish and shellfish, and play a role in extracting nutrients and toxic chemicals from water.

Coral reefs, are also susceptible to climate change from increased water temperatures and rising sea level. In many parts of the world reefs have undergone episodes of "bleaching" (loss of symbiotic algae) as a result of warmer local ocean temperatures. The most extreme example of these episodes was associated with the intense 1982-83 El Nino event, which killed extensive colonies of coral in the Pacific Ocean.

Commercially valuable marine fish stocks and the ecosystems that support them are also vulnerable to natural and anthropogenic changes in climate. Rising water temperatures increase risks to fish stocks already stressed by overharvesting. Fluctuations in some fish populations coincide with basin-scale physical changes in atmospheric forcing and surface ocean conditions (temperature, mixed-layer depth). In the northwest Atlantic Ocean, for example, interannual-to-interdecadal fluctuations in the physical environment and their effects on marine ecosystems are being examined as part of a larger effort to rebuild the once abundant Georges Bank cod and haddock stocks. In the northeast Pacific Ocean, salmon populations vary over decadal time scales in response to ocean-circulation changes in the California Current and the Coastal Gulf of Alaska System.

Adaptation Strategies

Adaptation strategies for coastal land loss fall broadly into four strategies:

- *hard-engineering*--building groins, sea walls and elevating coastal structures;
- *soft engineering*--nourishing beaches and stabilizing dunes;
- *management options*--applying (1) various development and land-use restrictions and (2) flood insurance; and
- *property protection strategies*--allowing individuals to protect their property.

In the case of future climate change and sea level rise, it may be more prudent to anticipate the impacts of potential sea level rise by taking action now. It is also nonetheless highly desirable to gain a better understanding of the adaptability of coastal ecosystems. Adaptation can be facilitated by identifying areas at high risk, improving understanding of the processes that build and erode shorelines, and developing integrated coastal ocean-prediction systems (see chapter 6).

Federal Coastal Zone Management Act. One strategy is to factor sea level rise and changing climate into the integrated coastal resource management programs at various governmental levels so that precautionary measures will minimize the potential damage caused by climate change. The Federal Coastal Zone Management Act requires states to consider the problems of climate change and sea level rise in their programs.

Many states have already taken considerable measures to ensure that growth in the coastal zones and the potential loss of resources will be planned for and managed accordingly. Examples include policies addressing sea level rise, setback zones, standards for infrastructure development, research, and education.

Coastal Wetlands. Coastal wetlands naturally migrate in response to changes in sediment supply and relative sea level. However, it is unknown if the rate at which wetlands migrate is sufficient to survive sea level rise. Establishing wetland reserves and protected areas adjacent to current coastal wetlands can facilitate adaptation.

Maine requires removing development to allow the landward migration of coastal wetlands in dune areas. A few states recognize "rolling easements" along ocean shores to permit natural dune systems to migrate inland. Other states have decided that protecting private property from erosion is a high priority, and guarantee landowners the right to erect a bulkhead, even though doing so results in the loss of natural shorelines.

Coordinated studies of wetland systems along the eastern Gulf of Mexico and southern Atlantic coasts and changes in the Mississippi Delta provide credible estimates of the ability of coastal wetlands to adapt to sea level rise. Other research related to the vulnerability and adaptation of coastal systems includes: space-based geodesy studies to distinguish the long-term trends in sea level change due to glacial melting and ocean expansion from effects of post-glacial rebound and active tectonics; studies that test existing geological models of coastal erosion processes; studies of coastal hypoxia; and studies of the frequency, magnitude, and tracks of storms.

In addition, the U.S. Global Change Research Program is developing and validating methods for estimating the effects of global climate change on regional fishery resources and their supporting ecosystems. This program is also examining the reproductive dynamics of the sardine, anchovy, and mackerel stocks off the coasts of California, Chile, Spain, and West Africa.

Coral Reefs. The United States is active in the Coral Reef Initiative, which promotes the conservation and sustainable use of coral reefs and related ecosystems (mangroves and sea-grass beds) within the United States and throughout the world. The initiative will integrate research, assessment, monitoring, and management of reef ecosystems through better coordination of existing activities and the creation of new programs. Among other activities, this program will focus on improving our understanding of how reef ecosystems are affected by global climate change.

Research to Improve Preparedness. A Coastal Risk Assessment Data base has been developed to integrate seven physical/land/marine variables (elevation, coastal land forms, wave height, etc.) with six climatological variables (storm frequency, surge height, etc.) to better quantify the vulnerability of U.S. coastal zones to climate change. Approximately 30 percent of the Gulf Coast and 15 percent of the East Coast were ranked as highly vulnerable to erosion or inundation.

In urbanized and high-use recreational areas, coastal beaches are nourished with imported sand and are protected by structures. However, a better understanding of the effectiveness of various beach nourishment and protection methods is needed.

Improved planning for catastrophic events, improved building codes in high-risk coastal regions, widespread public education about the risks of living in coastal zones, and limiting certain kinds of development in high-risk zones are additional adaptation strategies. Research to understand and forecast the response of living resources to climate-induced shifts will better position managers to deal with anticipated changes in fisheries and their habitats.

Water Supplies

Society depends on water for consumption, industry, transportation, and energy. Future climate change will affect water supplies unevenly, depending on regional and local weather, soils, topography, vegetation, hydrology, hydrogeology, and other factors.

Model calculations suggest increases in average global precipitation and the frequency of intense rainfall events, and a marked decrease in soil moisture over some mid-latitude continental regions during the summer (Figure 5-2). To a large extent the impact of climate change on water supplies is still unknown.

The 1994-97 period saw a significant rise in the number and scope of federal, state, and local efforts to integrate climate variability and its impacts on water supplies into the

planning, design, and management of water-supply systems throughout the United States. These efforts stem from recent extreme floods and droughts and the recognition by many scientists of the likely significant impact of climate change on precipitation.

For example, the winter storms of December 1996 and January 1997 created flood conditions in several western states, disrupting water-treatment facilities and contaminating surface- and ground-water sources. More recently, in April 1997 severe floods in North Dakota dangerously contaminated drinking-water supplies in Grand Forks and the surrounding areas. Recent failures of agricultural waste-containment facilities, including farm ponds, in the eastern United States have contaminated adjacent streams and rivers that are the only sources of drinking water for communities downstream. Flooding in agricultural areas tends to increase the likelihood of the migration of pesticides into drinking-water supplies, while flooding in urban areas increases the risk of contamination by hazardous wastes.

Vulnerability

Many factors are straining U.S. water resources and leading to increased competition among a wide variety of different uses and users of water. For example, human demands for water are increasingly in conflict with the needs of natural ecosystems, degrading the quality and depleting the quantity of water. In addition, water infrastructure in many urban areas is aging. Climate change will exacerbate these problems.

Studies have been conducted to assess the vulnerability of the major U.S. river basins to flooding and drought, disruptions in water supply, hydropower reductions, ground-water overdrafts, and extreme events. Among the most vulnerable systems are those in the western United States, particularly, the Great Basin, California, Missouri, Arkansas, Texas Gulf, Rio Grande, and lower Colorado. Arid basins could experience the largest relative change in water flow from climate change. Even small reductions in water availability could be significant, may be highly expensive to remedy, and could affect the social and economic well-being of communities in those areas.

For example, reduced surface-water flow may impede or may even render current transportation routes and waste disposal practices impractical and will block the migration of fish and other water-bound species. The drawing down of ground-water levels may result in land subsidence, saltwater intrusion into freshwater aquifers, and the loss of surface-water systems and associated wetlands. Changes in hydrologic regimes may also indirectly degrade the health of ecosystems, through increased nutrient loads, eutrophication, erosion, and other processes.

At the other end of the scale, regions traditionally considered to be rich in water may experience increased demands for domestic and agricultural water uses.

Adaptation Strategies

The United States has made a firm commitment to address issues related to water supply and management within the context of ecosystem management and watershed

planning. Many institutional arrangements for managing and allocating water resources have evolved over the past 150 years as agricultural, hydropower, and industrial development supported an expanding economy. Policies were designed for managing potential water scarcity, and the industrial, hydroelectric, and agricultural sectors increased the efficiency of their use of water.

Primary among the water-resource use issues is the realignment of incentives to conserve water as more efficient delivery and use systems are developed. Still, many existing predictive tools (climate, watershed, and aquatic ecosystems models) are not sufficiently developed to predict potential water shortages or potential system responses to them. Most techniques of hydrologic analysis used in water project planning are based on the assumption of an unchanging climate.

Water-resource managers need improved methods for assessing the sensitivity of the systems they manage to seasonal and longer-term variations in weather and climate. Equally important is the ongoing development of methods for evaluating the risk or uncertainty associated with such assessments. To facilitate adaptation to changes in water resources caused by climate change, the federal government, in cooperation with state and local agencies, is focusing on the following steps toward improving water-resource planning and management both to help relieve existing stresses and to prepare for climate change.

Development of New Analytical Tools and Data Bases The U.S. Army Corps of Engineers' Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies takes long-term climate changes into consideration (USACE 1983). The Corps devised the concept of "Drought Preparedness Studies" to be used when nonstructural and nonfederal solutions are needed. It uses computer models and hydrological trends to assist in water management decision making.

The development, dissemination, and use of new modeling and forecasting tools facilitate the analysis and prediction of hydrological response to change. For example, the Army Corps' 1994 "Comprehensive Guide to Water Management Models" covers the significant hydrologic and reservoir system models used by federal governments and academia. Additionally, the U.S. Geological Survey developed a historical data base of most U.S. rivers and streams, based on stream-flow gauges unimpaired by other human-made structures. This allows regional water planners to evaluate the variability of natural stream flows.

Adoption of Demand-Management and Water-Conservation Practices The Energy Policy Act of 1992 requires each federal agency to implement by 2005 all water-conservation measures that have a payback period of ten years or less. The interagency Western Water Policy Review Council was created to study and advise the nineteen semi-arid western states on implementing these measures, including the "water banks" that Arizona, California, Idaho, and Oregon have created to facilitate the storage, transfer, and distribution of water.

In 1993, following the Interagency Floodplain Management Review Committee (the "Galloway Commission") report on the 1993 Mississippi floods, the U.S. government created the Flood Plain Management Task Force. The task force assessed flood damages and attempted to create a balance among natural and human uses of flood plains and their related watersheds that would meet the nation's social and environmental goals. An interagency review of the task force envisions future flood plain use in which human activity is attuned to flood cycles. For example:

- Development in commonly flooded areas would be curtailed and gradually replaced with recreational areas.
- Critical infrastructure, such as roadways and water-treatment facilities, would be elevated, protected, or otherwise designed to withstand floods.
- Larger urban areas would remain protected behind large levees, but would incur a greater proportion of expenses for maintenance.
- Science and technology would better assist water planning through a wide range of mechanisms, from creating a computerized data base of flood-prone structures to developing hydrological, hydraulic, and meteorological models.

Basinwide Management of Reservoirs. The 1995 Bureau of Reclamation-State of Texas Memo of Understanding commits the Tennessee Valley Authority and the upper Colorado River system to cooperate to provide local water users with technical assistance and other support necessary to implement statewide practices to improve water quality and availability. By operating reservoirs within the same basin as a single system, rather than individually, the two programs will greatly enhance the efficiency and flexibility of their operations.

Improved Information and Models Many studies are designed to develop the capability of predicting the hydrometeorological and water resource responses to climate variability and change across the range of environmental conditions existing in the United States. Evaluation of water planning and decision making in a number of studies incorporates IPCC models into regional water supply assessments. These studies quantify and predict hydrological changes resulting from various IPCC model scenarios, highlight areas for improvement in global circulation models, and reveal potential sensitivities in regional water systems that could cause future concern. The U.S. Global Change Research Program is supporting multidisciplinary studies for creating regional "mesoscale" climate models that can predict the impacts of climate change on water supplies, wetlands, fisheries, and hydropower (see chapter 6).

"Lightly Managed" Ecosystems

Effective ecosystem management recognizes the importance of understanding how each of the living and nonliving parts of an ecosystem contributes to, and is affected by, the functioning of the whole system and how the system responds to stress. "Lightly managed" ecosystems are those natural systems with little or no direct management in

comparison to agricultural and urban lands. They include wilderness areas, preserves, wetlands, national parks and wildlife refuges, some coastal systems, alpine tundra, and some economically marginal forests.

Vulnerability

Certain characteristics of small, "lightly managed" ecosystems--such as being isolated or fragmented, containing sensitive species, or already experiencing considerable stress from pollution and geographic fragmentation--make them extremely vulnerable to climate change. Changes in the availability and quality of surface and ground water and in atmospheric deposition may further strain the function and limit the productivity of ecosystems.

Federally protected natural areas have become repositories for some of the nation's rarest species. However, these areas are subject to increased stresses from activities that occur both within and outside their boundaries. Climate change may realign the geographical environmental boundaries of these natural areas, while the boundaries that define their management and degree of protection remain fixed. As a result, some areas may become incapable of providing the benefits or serving the functions for which they were originally established, such as maintaining their unique or distinctive character, protecting rare species and other biological resources, and maintaining the quality and availability of other services, such as nature study or recreation.

Overall, as much as 80 percent of the land in the United States may shift to a new vegetation zone. If climate change accelerates habitat change or proceeds so rapidly that some species cannot adapt quickly enough, the rate of extinction of species may rise, and overall biodiversity may decline. Isolated species may find themselves in climate zones no longer suitable for their survival.

Some "Lightly Managed" Ecosystems Vulnerable to Climate Change

Florida Everglades

Vast mangrove swamps act as a buffer between the Atlantic Ocean's salt water and the Everglades' fresh water. In 1992, the World Wildlife Fund predicted that the Everglades' mangroves would become extinct because of their inability to adapt fast enough to keep up with the rising sea levels (Ellison 1996). These swamps were devastated by Hurricane Andrew in 1992; further saltwater intrusion will severely deplete the Everglades' remaining freshwater ecosystems.

Glacier National Park

In northwestern Montana, plant species characteristic of several floral provinces live together under the influence of maritime and continental climatic regimes. The higher regional temperatures from large-scale warming may subject high-elevation plants to habitat shifts that threaten their existence. Moreover, alpine glaciers, the main attraction of Glacier National Park, may be greatly diminished in size with increased air temperatures. Melting glaciers could transform the surrounding environment and could disrupt the terrestrial and aquatic ecosystems that constitute the park's primary tourist attractions.

California Parks and Wilderness Areas

Research carried out in conjunction with the National Park Service's Global Change Program has demonstrated that the giant Sequoia tree, a charismatic element of California parks, was absent from its current range during past periods of warm, dry climates and only colonized its present habitat about 4,500

years ago, when wetter and cooler climates prevailed. Future climate warming and/or drier conditions could have additional impacts on the giant Sequoia and on critical tree species in other national parks (Anderson and Smith 1994).

Sierra Nevada

The Sierra Nevada Ecosystem Project's 1996 report to Congress assessed the status of the entire Sierra Nevada ecosystem, including Yosemite, Sequoia, and Kings Canyon National Parks (CWWR 1996). Among the report's conclusions is that the steep elevational gradient in these parks makes them highly vulnerable to climate change.

Some of the most vulnerable ecosystems are in the currently dry continental interior, where climate change models predict aridity will increase significantly. Vegetation on coastal margins may also be at risk from the flooding and saltwater intrusion accompanying rising sea levels, or from increases in damaging storms. Plant communities with small or highly fragmented ranges may be lost, such as those at the upper elevations of mountains with no clearly discernible migration routes.

While evidence of the survival of pockets of temperate species from previous ice ages indicates that these glacial relic communities may survive radical climate change, models are not sufficiently sophisticated to enable scientists to predict future events in forest communities. For example, some natural forest ecosystems may rotate rapidly through a change in dominant canopy species, similar to the disappearance of the American chestnut from the forest canopy in the 1920s. Certain species and unique populations will most likely become isolated if climate change is too rapid. In many cases, adaptation will depend on the availability of a wide gene pool within the species.

Adaptation Strategies

The ability of humans to protect natural areas and biodiversity from large-scale climate change is currently limited. For example, little information exists about the probable timing, rate, or geographical extent of climate change. Likewise, there is limited understanding about which species are most sensitive to climate change, which could be saved, how to restore habitats or entire ecosystems, and what lands will be most valuable as preserves under varying climate change scenarios.

To facilitate adaptations to climate change in natural areas, the U.S. government is coordinating large-scale information gathering efforts (including research, inventory, and monitoring options) and is evaluating management measures. Research is being coordinated on species' sensitivity to climate change, restoration and translocation ecology, the design and effectiveness of migratory corridors or protective buffer zones, the development of ecological models, and the effects of elevated CO₂ concentrations on plants and animals.

The 1995 publication of the *Global Biodiversity Assessment*, to which the United States was a major contributor, provides an unprecedented baseline of information against which the impacts of climate change on species can be monitored (Heywood and Watson 1995). Under the U.S. Global Change Research Program, contributing research on the

adaptation of natural ecosystems to global change includes forest health monitoring; studies on threatened, endangered, and sensitive species; and research into the physiological basis of resistance to drought, ultraviolet radiation, and other stresses.

Through its Man and the Biosphere Program, the United States is also assisting in the development of the Biosphere Reserve Integrated Monitoring Network in Europe and North America. This pilot program establishes electronic linkages among the 170 biosphere reserves in Europe and North America for monitoring biodiversity and global change. If the program is successful, it will serve as a model for other biosphere reserves throughout the world.

Ecological Research and Assessment. U.S. agencies are developing programs to fill key gaps in the understanding of ecosystem functions and how they may be protected, restored, and enhanced at small spatial scales. Agency programs include:

- *The U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program*--Estimates the current condition of U.S. ecological resources, monitors indicators of pollutant exposure and habitat, and provides ecological status and trends reports to managers and the public.
- *The U.S. Fish and Wildlife Service's Gap Analysis Project*--Aims to prevent species extinctions by promoting protection of species-rich areas and unprotected vegetation types before they are threatened.
- *The National Science Foundation's Long-Term Ecological Research Program*--Focuses on eighteen sites and five core research categories, measuring such traits as primary productivity, nutrient cycling, site disturbance, population distribution, and accumulation of organic matter. The spatial and temporal scales of these processes--decades to centuries--make this program's activities especially important for climate change and adaptation-related research.
- *The National Park Service's series of research programs in Glacier, Rocky Mountain, Sequoia, and several other parks*--Assesses the impacts of climate change and plans for potential adaptation. In Rocky Mountain National Park, a regional hydroecological simulation system, linked with a general circulation model, was used to simulate weather and climate change over the Rocky Mountain States and relate future climate to ecosystem changes. Through coordinated field and modeling studies, researchers have shown the forest-tundra mountain ecotone is spatially heterogeneous and can be extremely vulnerable to climate change, yielding specific levels of sensitivity to different stresses for patch forest, closed forest and krummholz habitats. These data allow park managers to plan adaptive strategies for short- and long-term park management.

In addition to these agency programs, a partnership of seven federal agencies is contributing to this ecosystem research and assessment effort through a National

Environmental Monitoring and Research Initiative, which will provide a comprehensive evaluation of our nation's environmental resources and its ecological systems. This, in turn, will produce a sound scientific information base to support natural resource assessment and decision making.

Forests

Forests cover roughly one-third of the U.S. land area and more than 40 percent of the eastern portion of the country. They shape much of the natural and urban environment and provide the basis for a substantial forest products industry.

Over historical and long-term ecological time scales, forest ecosystems and the major species of trees that comprise them are extremely susceptible to climate change. Forests have shifted distributions in response to natural climate changes, often with a reassembly of species into a community of tree species completely unlike any known today.

One of the greatest concerns is that the human-induced build-up of greenhouse gases in the atmosphere will drive climate changes that are many times more rapid than naturally occurring past changes. Many tree species may be unable to migrate fast enough in response to projected changes in precipitation and temperature, especially at the southern margins of major biomes. The 1995 IPCC report estimated that roughly one-third of the world's tree species will change their distribution in a world where carbon dioxide concentrations are double preindustrial levels (IPCC 1995b).

Vulnerability

If the climatic regime of forest species changes significantly, they could suffer declining growth rates and increased mortality from temperature, moisture, and drought stresses, and increased damage from insects, disease, and fires. Climate change may shift the optimum growing range for some North American forest species a great distance from their current range, over a relatively short period of time. Such a shift would almost certainly exceed the ability of less intensively managed forests to migrate.

It is not yet known how different species may respond to conditions found outside their current ranges, or even if the current ranges are optimal for each species. Some research suggests that various species may be more adaptable to climate changes than their current range indicates. Some plants' responses are caused by differential effects of climate on the growth and regeneration of locally abundant species and genotypes; for other plants, climate change facilitates plant migration resulting in a new geographical distribution.

Terrestrial biomes will not react to climate change en masse. Individual tree species respond to climate changes at widely different rates. For example, woody species dominating temperate forests typically shift ranges as slowly as 50-400 meters (55-437 yards) a year. In contrast, the IPCC emission scenarios estimate rates of climatic change over the next century that would necessitate forests to migrate 150-550 kilometers (250-

915 miles) northwards, or 150-550 meters (164-601 yards) higher in elevation to stay within the same climate zone. These predicted rates are more than ten times faster than previously documented rates of migrations if an elevation gradient is not available.

The spread of tree species is often limited by the rate of seed dispersal and by the availability of appropriate soil moisture and other habitat conditions. Human development has greatly diminished the number of sites available for species to recolonize in response to human-driven climate changes and may create insurmountable barriers for many species' migrations.

Forests in locations already subject to droughts, fire, and wind damage will be highly vulnerable to depopulation or to changes in species composition and community structure if the frequency or intensity of these stressors increases. In boreal forests and tundra ecosystems, the release of CO₂ from permafrost soils due to a rise in annual temperatures could change these biomes from net sinks to net sources of carbon.

Elevated CO₂ levels, and the increases in the efficiency of water use that attend those levels, may raise the productivity of some forests, though it is unknown how large or prolonged the effect will be over long time frames. Some estimates developed through carbon flux models suggest that growth increases of 16 percent or more may accrue by the time CO₂ emissions double. However, the rate of carbon uptake by forests will not be linear, and limited soil nutrients may prevent such increases. Other effects of climate change--water shortages, pest activity, and fires--may also effectively decrease net primary productivity and may affect the distributions of forest types.

Adaptation Strategies

Government intervention to facilitate adaptation over short time frames may at present be impractical or limited. Even timber-industry forests are not intensively managed by the standards of annual agricultural crops. Furthermore, on large areas of public forest lands, such as wilderness areas, even a minimal management response may itself be viewed as incompatible with the goals for which the forests are held. Focusing forest management on sustaining ecosystem structure and function will promote future forest productivity, health, and diversity in the face of such stresses as climate change.

The federal government is considering several programs to mitigate negative impacts as U.S. forests respond to long-term changes in climate. Research focusing on the development of high-quality forest product species continues to develop suites of varieties adapted to greater levels of stress, both in the West as well as in the Southeast. Studies are under way to determine how changes in atmospheric chemistry affect tree growth and how to increase the U.S. carbon sink. Application of modern forestry practices to reduce damage due to harvesting and substitution of nontimber products are also potential adaptation options.

A national effort to collect and conserve a wide variety of forest species' seeds would ensure that the means are available to respond to the potential loss of forest species or

populations due to climate change. Some arboretums, universities, and U.S. Forest Service researchers already have limited programs associated with threatened or endangered forest species. However, an expanded and enhanced forest seed bank program with forest genetics research would greatly help the process. Seed collections should represent the variety of genotypes for each species. While maintaining the large quantities of seeds needed for a major replanting would be an unrealistically costly goal, the systematic storage of seeds would be valuable to commercial tree breeding and for biotechnology efforts in tree improvement.

Given the evidence that northern forests may be accumulating carbon from the atmosphere, one idea under intensive study is that of "afforestation"--planting additional forest lands to counterbalance the emission-based atmospheric input. The U.S. Department of Agriculture's Forest Service has provided a range of working estimates on how much carbon various forests in the United States will take up over the next fifty to one hundred years. It has concluded that significant amounts of currently poorly stocked forest land could be afforested for increased carbon sequestration. Ameliorating the social pressures that drive the conversion of forests to developed and urban uses may further reduce CO₂ emissions from deforestation.

Several prerequisites need to be addressed before any new adaptive measures are undertaken in the field of forestry. These include (1) a better understanding of the role of forests in the overall global carbon cycle; (2) the response of various forest species to rapid climate change, drought and flooding, and other environmental stresses; and (3) better monitoring methods to track the growth and decline of U.S. modern forests. Toward these goals, intensive studies of carbon cycling are being conducted using newly developed carbon models and field experiments of carbon fluxes in different terrestrial settings. And better models are being developed for predicting the responses of forest species to climate change. Retrospective studies of historical forest distribution shifts are helping to validate these models.

Human Health and Climate Change

Several expert bodies, including the IPCC and the World Health Organization, have expressed a growing concern about the potential adverse effects of climate change on human health. The IPCC has concluded that these effects will be diverse and will occur via direct and indirect pathways. These conclusions are based on information on scientific relationships between climate and human health; relatively few quantitative studies have applied these relationships to projected climate changes.

There are great difficulties in estimating potential health outcomes due to climate change. Some aspects of climate change will most likely lie outside the range of recorded human health experience, and the ability of models to project regional climate changes is still limited. Moreover, it is imperative to view the impacts of climate change on infectious diseases within the context of other key determinants of disease.

Human populations differ greatly in their environmental circumstances, social resources, and preexisting health status and, therefore, in their vulnerability to climate-induced stress. For example, the number of additional cases of disease due to a climate-related increase in potential transmission would depend on prior contact with the disease (i.e., immune status of the population), general biological resilience, (e.g., nutritional status of the population), population density, and patterns of interpersonal contact. Social and public health infrastructure and health-care resources will also mitigate the impact.

In addition, the control of certain diseases is becoming more difficult due to increases in antibiotic and drug resistance and decreases in the effectiveness of vector control methods (e.g., increasing pesticide resistance). Many of these factors are changing over time, so it is inevitably difficult to assess the health impacts of climate change.

Vulnerability

Heat-related Mortality. Climate change is expected to increase the frequency and intensity of extremely hot days, which may increase the number of heat-related deaths. Research on forty-four U.S. cities found that excess heat-related mortality could increase by 70-150 percent over an estimated baseline of about 1,800 deaths, even if the population acclimates somewhat to warmer temperatures. This estimate did not account for increased use of air conditioning or population growth. While decreases in winter cold-related deaths are also expected with a general warming, research to date suggests that these decreases may only partly offset the increases in heat-related mortality.

Infectious Diseases. Climate affects infectious microbes and the insects and animals that carry them, and is a major factor in the geographic range of most disease vectors. Fluctuations in local weather conditions often determine the timing and intensity of disease outbreaks. In addition, the effects of climate on regional vegetation and food supplies, animals, and ecological relationships may also indirectly increase risks of and susceptibility to certain diseases.

Climate change is expected to result in a net increase in the geographic distribution of disease vectors and to change the life-cycle dynamics of both vectors and infectious agents. As a result, the potential transmission of many vector-borne diseases is likely to increase. Globally, the population living within a potential malaria transmission zone could increase from 45 to 60 percent by 2100, with a possible 50-80 million additional malaria cases relative to an assumed annual baseline of 500 million cases.

Air Pollution Health Risks. Degraded air quality has been associated with respiratory illnesses, aggravation of existing cardiovascular disease, and premature death.

The influence of meteorological conditions, particularly temperature, on ozone concentrations has been well established. The relatively high ozone levels in 1988 and 1995 were most likely due in part to the hot, dry, stagnant conditions that occurred in some areas of the country. In 1995, about 71 million people lived in counties with air quality that did not meet the health-based ozone standard.

Other pollutants that involve atmospheric reactions may also depend in part on meteorological variables. Changes in regional temperature, precipitation patterns, clouds, wind speed and direction, and atmospheric water vapor--all of which depend on climate--may affect future levels of air pollution.

Adaptation Strategies

To confront these complex health threats, the Administration has taken a series of bold, innovative policy actions, through the National Science and Technology Council (NSTC) Directive. In 1995, NSTC published *Infectious Diseases--A Global Health Threat* and held a conference on Human Health and Climate Change. And in 1996, NSTC and the National Academy of Sciences published the second report in a series entitled *Proceedings of the Conference on Human Health and Global Climate Change* (NSTC/NAS 1996). Among the most important policy goals presented in these reports are to:

- Strengthen domestic infectious disease surveillance and response systems at federal, state, and local levels.
- Establish a global infectious disease surveillance response system.
- Strengthen research activities to improve diagnostics, treatment, and prevention.
- Ensure availability of drugs, vaccines, and diagnostic tests.
- Expand missions and establish authority of relevant U.S. agencies to contribute to a worldwide network.
- Promote public awareness of emerging infectious diseases.

These activities are being coordinated at the highest levels of the U.S. government through an Executive Order on Emerging Infectious Diseases, with leadership from the Centers for Disease Control and Prevention and the National Institutes of Health.

Research and Systematic Observation

The Second Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) finds that continuing anthropogenic emissions of carbon dioxide, methane, chlorofluorocarbons, and other greenhouse gases will lead to significant changes in climate, adverse consequences for environmental and natural resource systems, and increasing risks to and impacts on human health, water resources, coastal communities, forests, and agriculture. While the report presents many important results, it also recognizes many important uncertainties and knowledge gaps that pose significant challenges to meeting the qualifications enumerated in the Framework Convention on Climate Change (FCCC). Specifically, Article 2 notes that actions taken should achieve:

¼ stabilization of greenhouse gas concentrations at a level that would prevent dangerous anthropogenic 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.

Even though the United States is significantly cutting back spending to balance the national budget, appropriations for the U.S. Global Change Research Program have remained nearly constant, at about \$1.8 billion.

This sustained high-level funding has been possible because the executive and legislative branches of the U.S. government understand the importance of global environmental change issues to ensuring our continued economic prosperity, reducing human exposure to health-related stresses, and protecting the vitality of our natural resources.

This chapter describes U.S. support of research related to improving climate predictions, assessing the impacts of climate change and the potential to mitigate and adapt to its effects, and enhancing capabilities to analyze and project the socioeconomic implications of climate change. It also reports on U.S. participation in international research efforts and U.S. capacity-building in developing countries.

Key Findings of the IPCC's 1995 Second Assessment Report

U.S. scientists and research findings played a pivotal role in the development of the IPCC's 1995 Second Assessment Report (IPCC/WMO/UNEP 1996b). The following conclusions about climate change, its consequences, and the potential for adaptation and mitigation are extracted from this report. These findings provide important guidance for decision makers and identify critical research questions that need to be resolved.

Effects of Human Activities on Regional and Global Climate and on Sea Level

- Human activities are increasing atmospheric concentrations of CO₂ and other greenhouse gases, which tend to warm the atmosphere. In some regions, they are also increasing concentrations of aerosols, which have a cooling effect on regional levels.
- The Earth's climate is changing. The Earth's surface temperature this century has been as warm as or warmer than during any century since at least 1400 AD.
 - Global average surface temperature has increased by 0.3-0.6°C (about 0.5-1.0°F), with the last few decades being the warmest this century.
 - Sea level has risen 10-25 centimeters (about 4-10 inches).
 - Mountain glaciers have generally retreated.
- Models that account for observed increases in atmospheric concentrations of greenhouse gases and sulfate aerosols are simulating the recent history of observed changes in surface temperature and its vertical distribution with increasing realism.
- The balance of evidence suggests that there is a discernible human influence on global climate.

- Without specific policies that reduce the growth of greenhouse gas emissions, the Earth's average surface temperature is projected to increase by about 1.0-3.5°C (about 1.8-6.3°F) by 2100, a rate of warming that would probably be greater than during any comparable time interval during the last ten thousand years.
- The reliability of regional-scale predictions is still low, and the degree to which climate variability may change is uncertain.
- Sea level is projected to rise by 15-95 centimeters (about 6-38 inches) by 2100.
- The long atmospheric lifetimes of many greenhouse gases, coupled with the thermal inertia of the oceans, indicate that the warming effect of anthropogenic emissions will be long-lived.
- Even after a hypothetical stabilization of greenhouse gas concentrations, temperatures would continue to increase for several decades, and sea level would continue to rise for centuries.

Potential Health and Environmental Consequences of Climate Change

- Human-induced regional and global changes in temperature, precipitation, soil moisture, and sea level add important new stresses on ecological and socioeconomic systems that are already affected by pollution, increasing resource extraction, and nonsustainable management practices.
- Most systems are sensitive to both the magnitude and the rate of climate change.
- The projected changes in climate portend potentially disruptive impacts on the economy and quality of life for current and future generations.
 - Human health will be compromised by increases in the rate of heat-related mortality and in the potential for the spread of both vector-borne diseases (such as malaria, dengue, yellow fever, and encephalitis) and nonvector-borne diseases (such as cholera and salmonellosis).
 - Food security will be threatened, especially in the tropics and subtropics, where many of the world's poorest people live.
 - Water resources will be increasingly stressed, leading to substantial economic, social, and environmental costs, especially in regions that are already water-limited and where there is strong competition among users.
 - Human habitat will be lost where small islands and coastal plain and river areas are particularly vulnerable to sea level rise.
 - Natural ecosystems will be degraded as their composition, geographic distribution, and productivity shift along with the responses of individual species to changes in climate. This may lead to reductions in biological diversity and in the goods and services society derives from ecosystems.
- The socioeconomic conditions of developing countries make them more vulnerable to climate change than developed countries.
- The health and environmental impacts of climate change will be difficult to quantify with certainty because of uncertainties in regional climate projections, the complicating effects of multiple stresses, and a lack of understanding of some key processes.

Approaches for Mitigating or Adapting to Climate Change

- Adaptation, which involves adjustments in practices, processes, or structures of systems, can be helpful in reducing the adverse effects--or in preparing to take advantage of the beneficial effects--of changes in climate.

- Options for helping natural ecosystems adapt to new climate conditions (such as migration corridors) are limited, and their effectiveness is generally unproven.
 - Successful adaptation will depend upon education, technological advances, institutional arrangements, availability of financing, technology transfer, information exchange, and incorporation of climate change concerns into resource-use and development decisions. Potential adaptation options for many developing countries are extremely limited because of the limited availability of technological, economic, and societal capabilities.
 - Stabilizing atmospheric concentrations of CO₂ at three times or less its pre-industrial concentration will eventually require reducing human-induced emissions of greenhouse gases below today's levels.
 - Gains in energy efficiency of 10-30 percent above present levels are feasible over the next two to three decades, at little or no cost in many parts of the world, through technical conservation measures and improved management practices.
 - Significant reductions in net greenhouse gas emissions can be achieved by using an extensive array of technologies and policies that accelerate technology development, diffusion, and transfer in all sectors.
 - Flexible, cost-effective policies relying on economic incentives and instruments, as well as internationally coordinated instruments, can considerably reduce the costs of mitigating and adapting to the effects of climate change.
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Research Relating to the Prediction of Climate Change

One hundred years ago, rising CO₂ emissions spurred the Swedish scientist Svante Arrhenius to develop the first quantitative estimate of potential climate change from an enhanced greenhouse effect. That estimate is only slightly higher than current estimates for the global average change.

A central goal of the U.S. Global Change Research Program's research activities is improving regional and temporal resolution for predicting how climate will change over decades to centuries, and what its implications will be for society and the environment. The following sections and various Research Program publications describe current program efforts toward achieving this goal's six interlocking objectives.

Quantifying Natural and Human-Induced Factors Forcing Climate Change

Historical and geological records provide important insights into the natural factors that caused major changes in the climates of the past. Human activities have also been affecting atmospheric composition since the start of the Industrial Revolution more than two centuries ago. Current concentrations of CO₂ are about 30 percent above preindustrial levels as a result of the combustion of coal, oil, and natural gas and the clearing and plowing of land for cultivation. And methane concentrations are more than twice their preindustrial levels due to land- and energy-related activities.

The most important human-induced factors that are forcing climate change include gases and aerosols (small particles) that are modifying the Earth's atmospheric radiation (heat) balance. Changes in the land's surface and its vegetation are also altering the Earth's reflectivity and hydrology. Quantifying the character and trends in these climate-forcing factors is vital to understanding the causes of past changes, to predicting future changes more accurately, and to creating a basis for quantifying the effects of various mitigation options.

Recent research sponsored by the U.S. Global Change Research Program indicates that atmospheric aerosols--largely those emitted from human activities--exert a nonuniform cooling effect over the globe. On average, this effect may be counterbalancing about half of the expected warming from increased concentrations of greenhouse gases. The Research Program will continue to support studies of the cycles of greenhouse gases and of the generation and distribution of aerosols. In particular, the studies will focus on the role of terrestrial systems in carbon uptake, so as to refine understanding of the global carbon cycle. Observational studies of volcanic and solar variability will also be carried out to document the natural factors that influence climate.

U.S. Government Organizations Involved in Climate Change Issues

Adopted in 1990, the Global Change Research Act provides the mechanism for coordinating the research and policy development interests of the following U.S. government organizations:

Departments and Agencies*

Department of Agriculture

Agricultural Research Service
Cooperative State Research, Education, and Extension Service
Economic Research Service
Forest Service
Natural Resource Conservation Service

Department of Commerce

National Institute of Standards and Technology
National Oceanic and Atmospheric Administration

Department of Defense

Office of Naval Research
Cold Regions Research and Engineering Laboratory

Department of Energy

Office of Health and Environmental Research
Office of Policy and Analysis

Department of Health and Human Services

National Cancer Institute
National Institute of Environmental Health Sciences

Department of the Interior

U.S. Geological Survey

Department of State

Environmental Protection Agency

Office of Policy, Planning, and Evaluation

Office of Research and Development

National Aeronautics and Space Administration

Office of Mission to Planet Earth

National Science Foundation

Smithsonian Institution

Executive Offices of the President

Council of Economic Advisers

Office of Management and Budget

Office of Science and Technology Policy

* Departments and agencies that are not currently active in global climate research but that have been active in the past based on particular focused interests include the Department of Transportation's Federal Aviation Administration, the Department of Housing and Urban Development, the Agency for International Development, and the Tennessee Valley Authority.

Characterizing the Natural Variability of Climate

The paleoclimatic record reconstructed from ice cores and other sources of data provides evidence that the Earth's long-term climate varied significantly prior to about ten thousand years ago. Since then, long-term climate has been relatively stable, especially over the past few thousand years. It is important to understand why this is the case and what the prospects may be for returning to a significantly more variable climate.

Although long-term climate has been stable, the evidence suggests that, during the last glacial period, shorter-term climate changes occurred over just a few decades. Data from the past thousand years suggest that there have been interdecadal swings in climate, creating periods of drought in some regions and excessive moisture in others. Determining the character and causes of climate variability is thus essential as context for detecting climate changes and for determining the extent to which they are due to human activities. The national components of the international Climate Variations and Predictability and Past Global Changes program are being designed to improve understanding of natural changes in climate.

Recent research sponsored by the U.S. Global Change Research Program has provided information on past changes in the Earth's climate (from ice cores, lake-level data, and other indicators). Evidence suggests that the melting of numerous icebergs associated with glacial retreat could perturb ocean circulation patterns and result in relatively abrupt climate shifts over periods as short as decades. The research activities

will even more intensively focus on interactions involving the coupled atmosphere-ocean-ice system. The coupled processes appear to be important contributors to natural variations in climate on inter- and multi-decadal time scales.

The U.S. Research Program will also sponsor studies of solar variability as a climate-forcing factor on these same time scales. Efforts will continue to reconstruct past climates of the Earth, for comparison with the warm climates being experienced today.

Quantifying Climate System Processes and Feedbacks

A quantitative understanding of the climate system and the mechanisms and feedback processes that characterize its state is essential for determining how the atmosphere, oceans, and land surface will be affected by the projected changes in greenhouse gases, aerosols, land cover, and other factors that are changing the Earth's infrared radiation balance.

Available knowledge clearly indicates that changes in the radiation balance can be amplified or moderated by various climate feedback mechanisms, including water vapor, cloud, and sea ice feedbacks. These mechanisms control how strongly or weakly climate will respond to human-induced changes in forcing factors, and how rapidly or slowly the Earth's climate will change. Reducing uncertainty about the magnitude of climate feedbacks is thus critical to more accurately predicting how climate will change in response to alternative emission scenarios for greenhouse gases, and more accurately estimating regional patterns of climate change.

New and unexpected research results in U.S.-sponsored research programs indicate that significantly more solar radiation may be absorbed by the atmosphere, particularly under cloudy conditions, than is currently predicted by theory and climate models. Because this result is inconsistent with current understanding and hence controversial, it requires further observational confirmation. If confirmed, these new findings will require understanding the processes responsible for the currently unpredicted atmospheric solar absorption and a reanalysis of the Earth's radiation balance. The end result could be a significant improvement in climate models.

Improving Model Predictions of Climate Change

Because of the historical uniqueness of the ongoing human-induced changes in atmospheric composition, predictions of future conditions for particular scenarios require the use of numerical, computer-based Earth system models. Over the past ten years, as a result of the Research Program's sponsorship, atmospheric general circulation models (GCMs) have improved significantly. More accurate simulations of past climate conditions are helping to increase confidence in the models by providing explanations for past changes and by quantifying human influences on recent climate.

These ocean and atmospheric models have strong potential for continuing advances through improved representations of critical climate processes and finer model resolution for regional-scale predictions. However, today's GCMs need to be augmented by representations of the land surface, vegetation, chemistry, and the cryosphere (glaciers, snow, and ice), and must be based on a comprehensive scientific understanding of the functioning of the climate system.

The comprehensive understanding needed to create and apply these augmented models is developing rapidly through the observational, process, and modeling studies being conducted at several U.S. modeling centers. Research in support of this objective will continue to emphasize: incorporation of carefully tested modules in climate models; enhanced use of the most powerful computers; coupling of atmospheric, oceanic, and land surface components of the Earth's system; and testing and comparison of model simulations with observations as a means to evaluate the confidence that can be placed in model results. Studies to detect human-induced climate change will also be continued with additional studies of the contributions of various factors to climate change.

U.S. Objectives for Improving Climate Prediction Capabilities

To develop improved predictions and to assess their accuracy and significance, the climate change component of the U.S. Global Change Research Program is organized around six objectives:

1. Quantify the natural and human-induced factors that change atmospheric composition and radiation.
2. Characterize natural climate variability and the factors contributing to decadal and longer-period climate fluctuations.
3. Improve quantitative representations of climate-system mechanisms and feedback processes.
4. Improve scenario-driven predictions of climate change and identification of the human-induced component in the recent climate record.
5. Ensure the availability of a long-term, high-quality observational record of the state of the Earth system, its natural variability, and changes that are occurring over extended time scales.
6. Assemble and assess the emerging scientific information through national and international assessments.

Observing and Monitoring the Climate System

For the first time, the world community is capable of implementing an integrated global observing system that would provide future generations with a stronger basis for sustaining economic development while ensuring a healthy environment. Maintaining and

enhancing a global observing capability are critical to the international assessments of global change needed for guiding international policymaking.

Once missed, the opportunity for direct observations will be lost forever. Delays in deploying instruments and temporary cessations of observations present significant obstacles to advances in understanding, and postpone the gathering of data necessary for identifying the trends and mechanisms causing and influencing environmental change.

Over the past few years, the scientific community has been determining what measurements are needed and how best to make the observations. The United States has been participating in the planning efforts undertaken by the international scientific committees for the Global Climate Observing System, the Global Ocean Observing System, the Global Terrestrial Observing System, and the Committee on Earth-Observation Satellites.

Environmental Monitoring and Research Initiative

The National Science and Technology Council's Committee on Environment and Natural Resources and several other federal partners are developing a framework for linking U.S. environmental monitoring and research networks and programs, which account for about \$650 million in annual expenditures. By allowing comprehensive evaluation of U.S. environmental resources (e.g., air, water, soil, plants, animals, and ecosystems) for the first time, this national network will produce a sound scientific information base to support natural resource assessment and decision making. Work on this important initiative is well under way:

- In April 1996, a Mid-Atlantic Regional Workshop laid the basis for a pilot demonstration project, which will begin in 1997.
- In September 1996, a National Workshop (including representatives from state and local governments, industry, nongovernmental organizations, and academic experts) endorsed the draft framework. As part of the initiative, the Vice President charged the participants to develop a Report Card on the Health of the Nation's Ecosystems by 2001.
- An interagency Integrated Environmental Monitoring Team is coordinating program development and implementation, working closely with the Federal Geographic Data Committee, the Interagency Task Force on Monitoring of Water Quality, and other relevant organizations.

The U.S. Global Change Research Program is also actively involved in a cooperative international effort to design and implement a strategy for an integrated global observing system. The U.S. contribution to the satellite component of this integrated system will draw upon the resources of the National Aeronautics and Space Administration (NASA), the National Oceanic and Atmospheric Administration (NOAA),

and the Department of Defense (DoD). The NASA component will be carried out through the Earth-Observing System series of satellites, the centerpiece of NASA's Mission to Planet Earth and NASA's contribution to the Research Program. The NOAA and DoD contributions will be made through their operational weather satellite programs, a future component of which is being coordinated through the National Polar-Orbiting Environmental Satellite System program. (Because their principal justification is for operational applications, these contributions are not included within the Research Program's budget.) In addition, NASA and NOAA have established joint projects with the space agencies of Canada, Europe, Japan, and Russia to acquire, process, and share the satellite environmental data collected by these agencies.

To complement the enhancement of the satellite observing system, each nation will need to monitor surface conditions within its borders. Toward this end, the Committee on Environment and Natural Resources, working through its National Environmental Monitoring and Research Initiative, is increasing the coordination of U.S. environmental monitoring and related research networks. This initiative, which is proceeding with both national and regional planning activities, is expected to begin a process that, when fully developed, will provide the needed baseline information for documenting how U.S. ecosystems are being affected by environmental fluctuations and changes over periods from seasons to decades and longer.

Planned Launches for the Earth-Observing System of Satellites

NASA's contribution to international efforts to develop an integrated global observing system will be carried out through its Earth-Observing System series of satellites.

- Tropical Rainfall Measurement Mission, planned for launch in 1997, will provide the first observations of precipitation. Using active remote sensing from space over much of the world, especially over the oceans, this mission will help to improve predictions of the global hydrological cycle.
- The Landsat-7 mission, planned for launch in 1998, will provide high-spatial-resolution visible and infrared observations of the land surface.
- The AM1 and PM1 missions, with respective planned launches in 1998 and 2000, will provide crucial new measurements, or improvements of existing measurements, to characterize the atmosphere (including clouds, aerosols, and the radiation balance), the land surface (including ecosystems, land cover, and soils), and the oceans (including ocean color and sea ice extent).
- The EOS-CHEM1 mission, planned for launch in 2002, will provide detailed measurements of the chemical composition of the stratosphere and troposphere.

The meteorological and environmental monitoring networks being supported include:

- the network of surface and upper-air meteorological observation stations implemented by the United States and other nations under the aegis of the international World Weather Watch;
- the NOAA, NASA, and Environmental Protection Agency (EPA) networks of observing stations under the Global Atmosphere Watch, which provide observations of the concentrations of greenhouse gases and ozone-depleting substances;
- the internationally sponsored array of moored and drifting buoys that monitor surface and subsurface temperatures in the tropical Pacific Ocean to help detect the onset of El Niño events;
- the U.S. Department of Agriculture (USDA), Department of the Interior (DOI), and EPA networks that monitor the conditions of forests and other vegetation, soils, runoff, and water resources;
- NOAA's Surface Radiation Budget Network, which provides continuous measurements of the upward and downward components of visible and infrared radiation; and
- the UV radiation network of stations maintained by USDA, EPA, and NSF, which provide reference measurements for the United States and the polar regions that are starting to indicate the effects of ozone depletion.

Conducting Climate Assessments

Because climate is such a pervasive influence in human affairs, climate studies must be able to assemble and systematically evaluate diverse sets of information. The United States, through the U.S. Global Change Research Program, has joined other nations in participating in and supporting the IPCC as the mechanism for organizing climate change assessments.

Research Program agencies have assisted other nations in understanding their vulnerability to climate change through national studies and participation in the IPCC process. The Research Program will continue to participate actively in international assessments of climate change through the IPCC, and is planning comprehensive studies of national implications of climate change. In addition, research results will be provided to national and state-level planners and decision makers so that regional vulnerability can be evaluated.

Research on Impacts and Adaptation

Since the early 1980s, the United States has been conducting research on the potential impacts of climate change and options for adapting to those impacts. The U.S. Global Change Research Program's objective for impacts and adaptation research is to

“develop improved measures of the sensitivity, vulnerability, and adaptability of natural ecological systems and managed resource systems and project the consequences of climate change and long-term variations of the climate.”

Research on adaptation can be divided into two categories: (1) reactive adaptation, involving typical steps people may take in responding to changing climate (e.g., erecting dikes and switching crops); and (2) anticipatory adaptation, necessitating the enactment of policies perhaps many decades in advance of serious climate change (e.g., rolling easements that allow wetlands to migrate inland as sea level rises, or acquisition of land for future reservoir construction).

The most comprehensive research on impacts has focused on agriculture, forests, water resources, coastal zones, and human health, each of which is briefly discussed in this section. At present, more research focuses on the impacts of climate change than on adaptation options, although these two aspects may be examined in conjunction.

Agriculture and Forests

U.S. research on understanding the effects of global change on terrestrial systems includes studies of the interactions between terrestrial ecosystems and the atmosphere; the contributions of agricultural sources of methyl bromide to stratospheric ozone depletion, and possible substitutes for this fumigant; methane generation and nitrous oxide release; soil properties, including moisture, erosion, organic matter, nutrient fluxes, and microbes; the relationship of global change to forest and range fires, insects, and plant pathogens; agricultural management systems; and ground truthing of satellite measurements.

The United States also sponsors significant research on the effects of global climate change on the nation's and the world's agricultural food- and fiber-production systems, and forest and forest ecosystems. Programs include long-term studies addressing the structure, function, and management of forest and grassland ecosystems; research in applied sciences, including soils, climate, food and fiber crops, pest management, forests, fish and wildlife, and social sciences; implementation of ecosystem management on the national forests and grasslands; and human interaction with natural resources.

Recent Large-Scale Water Resource Management Studies

- In 1996, the U.S. Army Corps of Engineers undertook a study of the Water Management Implications of Global Warming. The series of published reports evaluated (1) the potential effects of global warming on the performance of the Tacoma (WA) and Boston (MA) water supply systems and on the Missouri, the Columbia, the Savannah, and the Apalachicola-Chattahoochee-Flint River basins; and (2) the relative effects of climate change and long-term growth in demand on system performance. The Corps is currently extending this series of studies to include the Great Lakes basin.

- Workshops held in early 1995 focused on identifying the information needs for evaluating approaches for managing the Great Lakes' water resources under different climate change scenarios. Participants used a decision-support system to test various management alternatives and evaluated options for regulating Lake Erie's water levels.
 - The Bureau of Reclamation undertook a number of studies to assess the sensitivity of hydrologic and water resources systems to changes in climate. The studies focused on fisheries, urban water supply, irrigation requirements, water quality, and basin water yield and covered different regions, including the southern Great Plains and the western United States. This program was completed in 1995.
 - The U.S. Geological Survey recently implemented a program addressing the Sensitivity of Water Resources (SOWR) to potential climate change and climate variability across the range of environmental conditions existing in the United States. The first SOWR study was conducted in the highly urbanized Delaware estuary. The second and third were conducted in western basins characterized by mountainous terrain, snowmelt-driven hydrographs, and demands for irrigated agriculture. Performed in conjunction with the Bureau of Reclamation, these studies focused on the Gunnison River basin (CO) and the American, Carson, and Truckee River basins (CA/NV). Current USGS research has shifted toward issues of shorter-term climate variability.
 - The Environmental Protection Agency and Tennessee Valley Authority have also undertaken assessments of the regional effects of global change on intensively managed natural terrestrial ecosystems. These studies have attempted to determine whether any major remediation actions would be warranted. They focused on such diverse uses as water supply, hydropower, recreation, navigation, water quality, and stream ecology, and concluded that the most critical issue may be thermal pollution.
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Water Resources

Numerous studies are under way on the effects of climate change on water resources. Overall, the studies focusing on GCM-based hydrologic sensitivity analyses and climate change vulnerability impact analyses have provided very little useful information for current water management decisions. The GCM output is still at too coarse a scale and is too inconsistent to be of value to the practitioners. Work to improve the GCMs and enhance their capabilities is under way to provide the information needed for long-term watershed planning and management, influencing design standards for levees and dams, and improving the basis for reservoir operations.

Ongoing studies of regional and national water management policies and procedures are exploring options for responding to both long-term and, more recently, short-term climate variability and resource demands. Most of the research uses a GCM-based sensitivity analysis framework, and some studies are using the latest 1995 IPCC transient scenarios.

These studies dovetail with the development of adaptive management techniques needed to complement those associated with possible larger impacts under more extreme scenarios. Hence, the U.S.-Canada Fluctuating Great Lake Levels Study, the Missouri River and Columbia River reallocation and regulation studies, the Florida Everglades Ecosystem Restoration study, and other agency initiatives reflect a heightened responsiveness to sound and innovative water management practices that strive to achieve sustainable development. Advanced methods, improved data sources, and knowledge about the interaction of ecosystems, hydrology, and climate are now being incorporated into the planning and design of comprehensive, long-term solutions. Climate variability and changes are becoming central elements of those designs and long-term plans.

Coastal Zones

The IPCC estimates that climate change is likely to add 15-95 centimeters (about 6-38 inches) to sea level by the year 2100. The United States is involved in research to further quantify sea level rise, its effects, and possible adaptive responses. Some monitoring of current trends is under way: gauges are recording tides at dozens of sites across the nation, and some coastal states are monitoring beach erosion rates.

A basic assessment of how much land and wetlands would be lost to various scenarios of sea level rise was largely completed by 1990, using scenarios of 50, 100, and 200 centimeters (20, 40, and 80 inches, respectively). The recent downward revision of sea level scenarios may imply a need to estimate the resources at risk from a 25-centimeter (10-inch) rise. Wetland erosion rates are only being monitored at a few isolated locations where erosion is unusually high, such as Louisiana and Blackwater Wildlife Refuge. More research on the ability of wetlands to keep up with an accelerating rise in sea level is necessary, and the rate at which rising sea level is leading to the replacement of natural shorelines with bulkheads should be monitored.

The implications of sea level rise for floodplain boundaries have been assessed for some specific locations. The National Flood Insurance Program has estimated the increased flood damages and flood insurance rates resulting from 30- and 90-centimeter (12- and 36-inch) rises in relative sea level. Research has also been conducted on the effects of sea level rise on saltwater intrusion in Delaware and San Francisco Bays, two of the four major U.S. water bodies whose water supplies appear to be most vulnerable to climate change. And various research grants have been provided to marine laboratories to assess the implications of warmer estuarine temperatures.

EPA has funded assessments of the cost of holding back the sea with a combination of dikes and beach nourishment, and the cost of abandoning areas due to sea level rises of 50, 100, and 200 centimeters. A new study funded by the electric power industry applies a cost-benefit model to estimate the costs of sea level rises of 33, 66, and 100 centimeters (13, 26, and 40 inches) on the assumption that areas will be abandoned or protected, depending on which is most cost-effective. And recent interest in the possibility of more intense storms along the coast has led to the Council on Environmental Quality's

coordination of an interagency series of studies to better determine the vulnerability of coastal communities and the insurance industry to climate change.

The United States also is engaged in a number of assessments of how communities can best adapt to sea level rise. The U.S. Coastal Zone Management Act requires states to develop strategies for responding to sea level rise. Thus far, a number of states have only estimated the loss of land under different scenarios. EPA has conducted legal research on possible avenues for ensuring that wetlands and beaches are able to survive rising sea level by migrating inland without infringing upon the private property interests of coastal property owners. In many cases, the appropriate adaptive response depends on the probability that the sea will rise by a given magnitude. Therefore, EPA has recently developed a probability distribution estimate of future sea level rise.

Human Health

Research into the relationships between climate change and human health has focused on three areas:

- identification and analysis of recent regional and local changes in climate to establish a causal link between climate and health and as analogs for future climate change impacts;
- development and validation of methods--ranging from extrapolation of empirical epidemiological dose-response data to integrated mathematical models--to forecast health impacts of climate change; and
- incorporation of health-related measurements in global, regional, and local monitoring activities.

Researchers have taken advantage of naturally occurring short-term fluctuations in climate, such as heat waves, to examine the effects of short-term exposures to extreme temperatures on human mortality. This research is being extended to include heat-related illnesses; weather-related mortality and morbidity in winter; confounding factors, such as air conditioning use, demographic characteristics, and mortality displacement; and the potential synergistic effects of air pollution.

Similarly, the El Niño/Southern Oscillation (ENSO) phenomenon continues to be studied, both as an analog for long-term climate change and to examine health consequences. For example, ENSO-related algal blooms serve as potential “environmental reservoirs” for microbes that cause cholera in humans. Insects and rodents have increased following the mild, wet winters associated with El Niño, with impacts occurring in areas where these animals act as pests in agriculture or as vectors for such diseases as malaria.

Integrated assessment models are being improved and expanded to cover a wider range of diseases mediated by ecological processes. For example, researchers are linking top-down health assessment models to dynamic life-history models to forecast changes in the epidemic potential of dengue-carrying mosquitos. Satellite/remote-sensing and

geographic information systems (GIS) are being used to explore infectious diseases, such as Lyme disease, hantavirus pulmonary syndrome, and cholera. Field studies are also being undertaken to evaluate suspected climate-disease linkages. Efforts are under way to further clarify and validate direct weather-related impacts on human health and, where possible, to extrapolate these to expected future climate changes.

The U.S. National Academy of Sciences is beginning a study of climate, infectious disease, and health. This study will critically evaluate the data behind suspected links between climate and health; identify useful weather, climate, and ecosystem information products and tools that can assist disease prevention and mitigation efforts; and suggest a global, multidisciplinary, international research strategy. Hot-Weather/Health Watch Warning Systems have been developed and implemented to facilitate emergency responses to extreme heat. Ongoing efforts are incorporating health indicators into global observing systems, to improve existing health monitoring systems and to apply communications technology in order to gather disease data more quickly and efficiently.

Predicting El Niño Events

The El Niño/Southern Oscillation (ENSO) cycle is an oscillation of relatively warm and cold waters, with available periods of two to seven years. The ENSO cycle influences the frequency, severity, and paths of storms in the Pacific Ocean, the viability of commercial fisheries off the coast of South America, and the occurrence of short-term regional droughts and floods in many parts of the world, including the United States.

The El Niño of 1986–87 is hypothesized to have been a key factor in the severe U.S. drought of 1988, which is estimated to have cost the national economy tens of billions of dollars. Furthermore, during the persistent El Niño conditions of 1991–95, parts of the United States were vulnerable to extended precipitation anomalies. The 1993 Mississippi and the 1995 California floods may have been the result of the anomalous extremes in El Niño behavior that began in 1990.

Recent scientific results have demonstrated the ability to predict the onset of El Niño events and to estimate rainfall in equatorial regions one to two years in advance. These predictions are already being used with success in many tropical countries to affect decisions on crop selection, planting schedules, and water resource allocations. For example, in 1987 agricultural production in northeastern Brazil dropped by 85 percent when rainfall fell to 70 percent of the historic average. In 1992, however, agricultural production was near normal, despite a similar decrease in rainfall, because farm-management practices were adapted on the basis of the forecast.

The U.S. Global Change Research Program led the world in developing the International Research Institute (IRI) for climate prediction of ENSO-related weather disturbances around the world. Representatives from forty countries met in Washington, D.C., to create the IRI and address the question of how scientific

information on ENSO can be translated into economic, water-supply, agricultural, and other planning decisions.

This work includes substantial efforts directed at extending the ENSO forecasts to middle latitudes—e.g., North America. Similar programs to predict and plan future ENSO-related weather anomalies are ongoing in the Pacific Northwest and in Utah and Idaho. Improved seasonal and interannual climate forecasts are expected to yield significant savings for the nation.

Research Relating to Mitigation and New Technologies

During the last twenty years, improvements in energy efficiency have fueled U.S. economic growth: energy intensity has decreased by 27 percent, while the economy has grown by nearly 56 percent. If energy intensity had stayed at 1972 levels, an additional \$30 billion would have been needed to fuel the economy's annual energy demands, and greenhouse gas emissions would have been substantially higher.

The United States is committed to improving energy efficiency and energy technologies in all critical market segments: commercial and residential buildings, transportation, industry, utilities, and government. The policies contained in the U.S. Climate Action Plan are aimed at transferring information on energy efficiency and energy technologies and creating an effective market for investing in existing or nearly commercially available technologies for reducing greenhouse gas emissions and protecting the carbon sinks both in the United States and abroad. A successful long-term strategy must ensure that a constant stream of improved technology is available and that market conditions favoring its adoption are not impeded.

The United States is investing strongly in research and development of promising technologies that will reduce greenhouse gas emissions. Research priorities to reduce energy demand include advanced building systems, transportation equipment systems, and manufacturing technologies. Research priorities for lower-carbon, energy-supply technologies include sustainable biomass energy systems, advanced natural gas turbines, fuel-cell technologies, more efficient clean-coal technologies, cogeneration systems, improved efficiency of energy-distribution and -storage systems, renewable-energy technologies, hydrogen fuel systems, and continued research into nuclear safety and waste disposal options that could maintain commercial nuclear power.

Research activities can be subdivided into those relating to solar and renewables, fossil fuels, nuclear and fusion, and energy efficiency. Efficient technologies include both those that reduce energy inputs required to provide the desired services, and also those that reduce resource inputs to provide a product. The United States has a diverse portfolio of investments in technology development. Some projects are taking place in national laboratories, and others are government-subsidized, direct grants to researchers. Recent

efforts have moved to cost-shared efforts and partnerships with industry and to cooperative agreements between national laboratories and industry.

Solar and Renewable-Energy Technologies

Solar and renewable-energy technologies currently supply about 7 percent of U.S. energy needs, a large portion of which comes from hydropower. Increasing this fraction will require additional technological developments, focusing particularly on the following technologies.

Thin-Film Technologies

Using thin-film materials for generating photovoltaic electricity offers a promising path to very low-cost energy. This process applies very thin layers of semiconductor materials--as thin as 1 micron, about 300 times thinner than conventional techniques--to low-cost backing materials, such as glass or stainless steel foil. Materials being evaluated include cadmium telluride, copper indium selenide, polycrystalline silicon, and gallium arsenide. Manufacturers can also take advantage of existing processes, such as those used to coat glass. While typical modules are made of cells wired into circuits, thin-film technology can produce a circuit as a single large piece.

Photovoltaic Technologies

Photovoltaics are already being used effectively in a broad range of applications, including off-grid electricity supply systems. Current photovoltaic research projects are focusing on producing new semiconductor materials; improving crystal growing techniques for creating lower-cost, higher-quality cells; and enhancing the performance of existing photovoltaic devices. Research is being conducted in partnerships with private firms and the DOE national laboratories.

Wind Systems

The U.S. government supports applied research in wind characteristics and the aerodynamics, structural dynamics, and materials of wind turbine systems. These systems will reduce carbon emissions by displacing bulk power, fossil-fueled systems.

Geothermal Technologies

The United States is also investing in basic and applied research on the use of U.S. geothermal resources to produce energy. This research includes monitoring and modeling geothermal production and its environmental impacts. Efforts are focused on improving exploration and drilling methods, the productivity and longevity of reservoirs, resistance to corrosion, and the design of energy-conversion systems.

Fuel Cells

Fuel-cell research is aimed at producing reliable and commercially competitive fuel cells to meet transportation and electricity generation demands. Research areas include developing on-board reformers, hydrogen storage devices, and power management devices.

Biomass for Direct Power

The industrial and commercial sectors are demonstrating both a need for fossil fuel substitutes and a desirability to be more independent of the fossil fuel power grid. In cooperation with DOE, DoD, and the Tennessee Valley Authority, EPA is integrating and demonstrating biomass to electricity systems for the nonutility sector. Initial systems will use waste biomass in gasification and gas cleanup systems that feed a turbine to generate electrical power. Future systems could use biomass plantations as well as waste products and could be used in new or retrofit applications.

Methane Use

Waste methane is a powerful greenhouse gas. Using methane to produce power in fuel cells could significantly reduce emissions and produce a clean, useful product. Demonstrations are being performed with commercial fuel cells at a landfill site and a wastewater digester. Methane emissions from animal waste lagoons are also being considered for recovery as a potential source of energy.

Fossil Fuels Energy Technology Research

Fossil fuels and the technologies that use them are in wide use, supplying approximately 85 percent of U.S. energy demand. Although these technologies are relatively mature, significant efficiency and environmental improvements can be made in the availability, recovery, and combustion of fossil fuels. Relatively small increases in efficiency can result in substantial reductions in greenhouse gas emissions, because fossil fuels are used very extensively.

Advanced Turbines

The United States is conducting research to increase the efficiency, performance, and reliability of gas turbines. Advances in materials sciences are enhancing the ability of turbine blades to operate in high temperatures or dirty environments. Computer and aerodynamic research activities are also improving blade shapes and machining techniques.

Clean, Efficient Transportation Fuels

A practical approach to meeting the goal of using hydrogen in fuel cells is to transition to hydrogen through a liquid fuel that could be used in conventional internal combustion engines. Methanol from biomass is a strong candidate for this transitional phase.

EPA, the University of California at Riverside, South Coast Air Quality Management District, and others are developing the Hynol process, which produces methanol from a wide variety of biomass sources. Hynol-produced fuel could provide transportation fuel into and through the 21st century.

Advanced Vehicles

The Presidential initiative “Partnership for a New Generation of Vehicles” is combining the resources of the “big three” U.S. automakers and more than a dozen federal organizations in a drive to develop a prototype hybrid electric vehicle (HEV) capable of providing 80 miles per gallon by 2004. DOE’s HEV Propulsion Program has signed independent contracts with General Motors, Ford, and Chrysler to produce production-feasible HEV propulsion systems by 1998, first-generation prototypes by 2000, and market-ready HEVs by 2003. The DOE program is funding approximately 50 percent of the development costs.

DOE’s Office of Advanced Automotive Technologies is focusing on developing electric and hybrid vehicle technologies, advanced-heat engines, alternative fuels, and advanced materials for application to all light-duty vehicles, including passenger automobiles. The goal is to drive these technologies to a point of maturity where auto manufacturers can incorporate them into the average family car.

Clean Coal

Research to dramatically increase the efficiency and environmental performance of coal use is critical to addressing climate change, both in the United States and internationally. Current research is focusing on developing technologies for coal cleaning, gasification, and fluidized bed combustion; capture, disposal, and use of CO₂; improved combustors; and enhanced recovery of coal-bed methane to reduce the risk of mine explosions.

Nuclear and Fusion Energy Technology Research

Nuclear power supplied about 7 percent of U.S. energy needs in 1990. U.S. policy is to maintain the safe operation of existing nuclear plants in the United States and abroad and to preserve the option to construct the next generation of nuclear energy plants. Toward these ends, the U.S. government is working with industry to ensure the safe operation of nuclear plants and safe storage of spent nuclear fuel.

Advanced Reactor and Nuclear Safety

The United States is working to develop next-generation, light-water nuclear reactors, with simplified designs and better engineered, passive safety systems. Advanced concepts include materials designed to prevent failure in case of an accident, and application of alternative solutions for use as the heat-exchange medium.

Fusion Energy

Working with U.S. industry and international partners, the U.S. research programs are creating materials and techniques to develop fusion as a safe, environmentally sound source of energy. Advanced research and development in the fusion program is providing high-technology spin-offs relating to such areas as superconducting materials, computer technologies, lasers, electronic diagnostic equipment, and high-frequency radio sources.

Energy Efficiency Research

The U.S. tradition of relatively low energy costs has promoted the world's strongest economy. This track record serves as the basis for continued U.S. research toward improved energy efficiency.

Building Shells

Improving the roofs, walls, windows, and foundations of buildings is critical to changing the buildings sector's energy consumption.

Windows and glazings research addresses the development of advanced fenestration technologies, such as spectrally selective coatings appropriate to regional climate conditions and electrochromic glazings (where window tint is controlled by an electrical signal). Research on walls, roofs, and foundations focuses on improving materials currently being used and investigating the use of other materials. Another focus of building shell research is developing CFC-free insulation materials.

Building Equipment

Building equipment research focuses on developing equipment and systems that offer greatly improved performance over existing systems. Research on heating, ventilation, and air-conditioning equipment covers all types of fuel sources--oil heat as well as electric and natural gas systems.

For example, research on advanced electric heat pumps, new natural gas heat pumps, and CFC-free refrigerants could improve the energy efficiency of building equipment; research on advanced lighting technologies could double the efficiency and lifetimes of current fluorescent lamps; and the use of fuel cells for building applications is an important new research area being investigated.

Building Systems

Building systems research focuses on integrating the building's equipment, appliances, and shell to maximize its entire performance. The U.S. research program is divided into three separate activities: Residential Building Systems, Commercial Building Systems, and Best Practices.

Current research activities include developing, demonstrating, and bringing to market energy-efficient and renewable-energy technologies. The savings from these technologies will be applied to construct new and retrofit existing buildings. Research efforts also include developing basic analytical and design tools and understanding buildings to enhance their design and construction.

High TEWI (Total Equivalent Warming Index) Refrigerants

Introduced as an alternative to the ozone-depleting substances being phased out under the Montreal Protocol and Clean Air Act Amendments of 1990, hydrofluorocarbons (HFCs) are the fastest-growing greenhouse gas emissions. EPA is researching some

environmentally benign alternative refrigerants, with the aim of increasing and demonstrating their energy efficiency and safety.

Industrial Efficiency

The U.S. government has formed partnerships with seven materials and process industries that together use more than 80 percent of all energy in manufacturing and generate more than 80 percent of U.S. waste and pollutants. The Industries of the Future program is working with the forest and paper, steel, aluminum, metal casting, glass, chemicals, and petroleum refining industries to create “technology development roadmaps” to support a long-term strategy.

The nation can substantially reduce greenhouse gas emissions by improving the efficiency of industrial combustion. Projects are now under way to develop oxy-fuel firing, advanced porous radiant (pebble) burners, ferrous scrap preheaters, and catalytic combustion. These technologies can reduce greenhouse gas emissions by burning less fuel, converting fuels to natural gas, and eliminating postcombustion controls (which may produce greenhouse gases).

Research Relating to Socioeconomic Causes and Effects

The goal of the U.S. government research programs is to develop improved measures of the sensitivity, vulnerability, and adaptability of socioeconomic systems, and project the societal implications of climate change and long-term natural variability (NSTC 1997). The vulnerability of U.S. socioeconomic systems to climate change depends in part on changes over time in population, technologies, economic development, and land-use patterns. Trends in these underlying factors will affect the degree to which climate change will alter food production, the quantity and quality of U.S. water resources, health, infrastructure, financial services, and economic activities dependent on natural resources.

U.S. research activities are focusing on increasing understanding about these underlying socioeconomic factors and human activities, and improving and extending methods and models to integrate information across ecological, physical, economic, and social science disciplines. This research and integration will enhance both projections of and human responses to climate change impacts, predictions of greenhouse gas emissions and sinks, and evaluation of policy options for better managing U.S. human and environmental systems.

Climate Change Contributions of and Consequences for Human Societies

Estimating changes in the climate system and their effects on human societies requires understanding and projecting the key socioeconomic factors driving those climate changes and assessing the effectiveness of policy measures.

Toward this end, the United States is developing methods and models for assessing technological innovation and diffusion; social values; the feasibility, costs, benefits, and

efficacy of alternative response strategies; and the role of information in decision making. The U.S. government is also carrying out research on different economic sectors and managed resources (e.g., water resources, agriculture, forestry, fisheries, energy, transportation, financial and insurance services, and coastal infrastructure), human health, and other nonmarket effects of climate change.

Health-related research is focusing on the incidence and spread of infectious diseases, and the effect of heat stress on mortality. Research on climate variability examines the vulnerability of society to the impacts of short-term climate fluctuations, or changes in the frequency and intensity of extreme climate events.

Other studies are designed to improve information and model the economic consequences of climate change impacts on freshwater habitats, coastal zones and coastal ecosystems, forests, rangelands, croplands, and deserts. These studies include assessments of alternative methods of management and their effect on the ability of ecosystems to adapt to rapid climate change.

Integrated Assessments: A Framework for Policymakers

The depth and breadth of information coming from research in the natural, social, and policy sciences necessitate developing methods for integrating this information into a form that is meaningful to the policy process. Integrated assessments provide a useful framework for pulling together the best available information from all of the sciences and explicitly modeling their linkages.

The United States is supporting a variety of efforts to refine and extend integrated assessment models, and to investigate the various interactions and interdependencies of the different components of climate change. For example, the Stanford-based Energy Modeling Forum brings together a variety of integrated assessment modeling teams and scientists, representatives of the policymaking community, and experts on the key individual components of climate change. The Forum is facilitating the comparison of various approaches to integrated assessment to evaluate their usefulness in developing and analyzing policies for responding to climate change, and in setting priorities for climate change research.

U.S. research activities also include developing and disseminating information on projected impacts and analytical tools to help regional and local planners and managers evaluate the effectiveness and viability of alternative approaches for mitigating or adapting to the consequences of climate change.

Interagency Analysis of Policy Initiatives

The U.S. government has established an interagency team to analyze issues associated with global climate change policy initiatives. This team is investigating the following key areas:

- alternative options for revenue recycling;
- methods for modeling growth and adjustment in response to policies;
- the impacts of policies on specific industries and the effects of technology options and trade patterns on these industries;
- implementation strategies and those characteristics that would make the results of policies deviate from modeling results;
- identification of the economy's technological response to policies and strategies for incorporating such a response into modeling efforts; and
- the effects of policies on other countries and incorporation of these effects into climate change policies.

International Research and Capacity Building

Effective global change research brings together scientists from around the world to assess, evaluate, and build on each other's work. U.S. scientists are closely collaborating with the international scientific community by participating in international research programs and research activities coordinated by multilateral organizations, particularly the IPCC, which is the primary vehicle for international cooperation on assessment of climate change issues.

U.S. participation in other international efforts to understand and assess the state of knowledge about global change includes building global change research capacity in developing countries, sharing data and information with the international scientific community, and collaborating on bilateral research projects.

International Research Programs

Three major international programs are addressing scientific questions related to the global environment: the World Climate Research Program, the International Geosphere-Biosphere Programme, and the Human Dimensions of Global Environmental Change Program. These programs have identified many of the key scientific problems that need to be addressed on a global scale; have developed the scientific rationale and plans for resolving these problems; and are providing an international framework within which research activities sponsored by the U.S. Global Change Research Program can both address national research objectives and provide key contributions to coordinated programs toward resolving global and regional scientific questions.

The World Climate Research Program

Jointly sponsored by the World Meteorological Organization (WMO), the Intergovernmental Oceanographic Commission (IOC), and the International Council of Scientific Unions (ICSU), this program seeks to determine to what extent transient climate variations are predictable and to lay the scientific foundation for predicting the response of Earth's climate to natural or human influences. In mid-1997, the United States will co-sponsor a major conference with the WMO, IOC, and ICSU, to review the program's progress to date and to determine if the program needs additional scientific direction.

The International Geosphere-Biosphere Programme

This ICSU-sponsored program focuses on acquiring basic scientific knowledge about the interactive processes of the Earth's biology and chemistry and their relationship to global change. It gives priority to key interactions and significant changes on time scales of decades to centuries that most affect the biosphere, that are most susceptible to human perturbations, and that will most likely lead to a practical, predictive capability.

International Human Dimensions Program

The ICSU has recently become a co-sponsor of this program, which was initiated under the aegis of the International Social Science Council. The Federal Republic of Germany has offered to host Secretariat, and is currently setting up IHDP offices in Bonn. The Scientific Committee for the IHDP is reevaluating and updating its draft scientific program, in consultation with IHDP national committees, including the U.S. National Committee under the National Academy of Sciences.

International Group of Funding Agencies for Global Change Research

IGFA's goal is to facilitate international global change research in natural, social, and economic sciences by bringing the perspective of national funding agencies to strategic planning and implementation of such research.

U.S. contributions to the IGFA's second Resource Assessment Survey include summarizing U.S. activities supporting global change research and providing information on U.S. research projects and their lead scientists. The IGFA will share this information with international global change research programs, to help them enhance communication with their U.S. colleagues.

The United States is also leading an IGFA Working Group that is examining the relationship between national agencies that fund global change research and those that fund development aid. The aim is to determine whether these two groups of agencies can work together more closely in areas where global change research and development interact.

Committee on Earth-Observation Satellites

The United States is striving actively (1) to optimize the benefits of spaceborne Earth observations through cooperation in mission planning in development of compatible data products, formats, services, applications and policies; (2) to serve as a focal point for international coordination of space-related Earth observation activities; and (3) to

encourage complementarity and compatibility among spaceborne Earth-observation systems.

In September 1996, CEOS and IGFA joined with other international organizations and experts in an In Situ Observations workshop sponsored by the Global Climate Observing System. At its November 1996 plenary meeting in Canberra, CEOS approved new directions for its activities on information systems and services, reviewed needs for protecting Earth-observation satellite frequencies, and asked its Working Group on Calibration/Validation to address relevant recommendations from the In Situ Observations workshop.

Multilateral Program Activities

The United States is providing substantial financial and technical support to environmental research conducted by the World Meteorological Organization and the United Nations Environment Program. It is also working with the IPCC to assess climate change mitigation and adaptation strategies. This environmental research is essential to the international global climate change negotiations under the United Nations Framework Convention on Climate Change, to Earth observations, to global climate modeling, and to the full international exchange of global climate data and information.

World Meteorological Organization

WMO coordinates, standardizes, and improves world meteorological activities and encourages the efficient exchange of meteorological information among countries throughout the world. As part of its activities, WMO has been actively engaged in various aspects of climate and climate change, with such programs as the World Climate Research Program and the World Climate Impacts Program. The United States provides significant support to WMO and is actively involved in ongoing observational activities and in planning for the WMO Global Climate Observing System. Along with the United Nations Environment Program, WMO has helped sponsor the scientific assessments of both climate change and ozone depletion.

United Nations Environment Program

One of UNEP's major climate change activities is designing and implementing a Global Environment Monitoring System, with a Global Resources Information Data Base component. This program links more than twenty-five major global monitoring networks, a number of which are established and supported by U.S. agencies. Along with WMO, UNEP has co-sponsored the scientific assessments of climate change and ozone depletion.

Intergovernmental Panel on Climate Change

The IPCC's climate change assessments draw upon thousands of scientists from more than 150 countries. U.S. Global Change Research Program projects and program-supported scientists have provided extensive scientific and technical input to these assessments, serving as lead authors, co-authors, contributors, and reviewers.

The IPCC's recently completed Second Assessment Report concludes that human activities are likely to have affected climate over the past century, that climate change is likely to become more pronounced over the next several decades, and that many natural ecological systems and managed natural-resource systems are vulnerable to climate change. The IPCC is planning to complete its Third Assessment Report by 2001.

The Subsidiary Body for Scientific and Technological Advice of the FCCC has recently asked the IPCC to prepare a number of technical papers and special reports to clarify issues under negotiation in the FCCC or to further articulate and integrate the vulnerability assessments presented in the Second Assessment Report. The United States will continue to be a strong participant in upcoming IPCC activities, encouraging an intensified focus on regional issues.

The United States continues to serve as co-chair of the IPCC Working Group II, and the U.S. Global Change Research Program provides the resources to support Working Group II's Technical Support Unit. The United States coordinates its IPCC-related activities on an interagency basis.

FCCC Subsidiary Body on Scientific and Technological Advice

Under the aegis of the SBSTA, Parties to the Convention agreed upon guidelines for preparing the developing countries' national communications to fulfill their obligations under the Convention to the Conference of the Parties. They also approved reporting guidelines for Activities Implemented Jointly, the pilot phase initiated by the First Conference of the Parties.

International Ozone Assessment

During 1994, the United States led the preparation of the international Scientific Assessment of Ozone Depletion, continuing a U.S. series started in the 1970s and internationalized in the 1980s. The most recent assessment compiled information about emissions of ozone-depleting substances, observed and predicted changes in ozone concentrations, the effects on the ozone layer of recent volcanic eruptions, the development and character of the Antarctic ozone hole, the increases in UV radiation that result from ozone depletion, the effects on the radiation balance (and thereby on climate) of changes in ozone concentrations, and the build-up and expected effects of substitute compounds.

The ozone assessments have provided crucial scientific information to negotiators of the Montreal Protocol on Substances That Deplete the Ozone Layer and its subsequent amendments and adjustments. As a follow-up to the overall assessment, a special assessment on the effects of subsonic and supersonic aircraft is currently being conducted by NASA and is expected to be completed by the end of 1997.

Regional Research and Related Capacity Building

The U.S. Global Change Research Program is making its research and related capabilities available to other regions and nations of the world to enable them to improve both their understanding of, and their capabilities to mitigate and adapt to, climate change. U.S. regional cooperation includes work in Southeast Asia, Sub-Saharan Africa, and the Americas. The Research Program is also helping developing countries and countries with economies in transition to build their capabilities to conduct global change research.

Inter-American Institute for Global Change Research

Following the entry into force of the Agreement to Establish the Inter-American Institute for Global Change Research (IAI) in 1994, the IAI Conference of the Parties selected a Scientific Advisory Committee, an Executive Council, an IAI Director, and a site for the IAI Directorate. The Director officially assumed his position, and the Directorate was opened at the National Space Research Institute of Brazil in March 1996.

The IAI has issued two calls for scientific proposals, and grants are currently being awarded. The results of these awarded proposals will serve as the first examples of IAI-fostered regional cooperation, which is expected to promote optimal use of available resources for global change research and to augment the scientific capacity of the region. Scientific data and information provided by IAI researchers will be managed as a common resource for the region and should provide baseline information for regional planning.

European Network

European researchers are responding to ENRICH's recently issued call for proposals with descriptions of EU activities that support future global change research in such areas as networking and infrastructure development.

Asia-Pacific Network

The January 1997 APN Workshop on Human Dimensions Issues in New Delhi identified potential topics for future research related to food security, freshwater supply and declining water quality, uncertainties regarding health status changes flowing from global change, and improvements in the flow of information to policymakers. These recommendations were addressed by the APN's Scientific Committee and during the March 1997 APN Inter-Governmental Meeting.

International Research Institute for Climate Prediction

The IRI will provide an integrating point for modeling, observations, process studies, and social science research conducted by many nations. Research will focus on predicting climate fluctuations and enhancing capabilities for adapting to existing fluctuations in climate, such as those associated with El Niño events. This work should provide insight into how society might adapt to longer-term climate change.

During the November 1995 "International Forum on Forecasting El Niño: Launching an International Research Institute," held in Washington, D.C., the United States offered to provide a site for the IRI's core facility. Columbia University's Lamont-Doherty Earth Observatory, in partnership with the Scripps Institution of Oceanography,

will house the core facility and will make its capabilities available to the international community.

The U.S. Global Change Research Program has been cooperating with a number of countries and organizations interested in advancing the IRI. Pilot applications are being developed in collaboration with existing regional networks, such as the IAI. In November 1996, two workshops were convened as the initial steps in designing and implementing such pilot activities in Southern Africa and the Middle Americas.

Global Change System for Analysis, Research, and Training

U.S. leadership in and funding support for the START program reflect the continuing U.S. commitment to build capacities for global change research in the developing world. A joint initiative of the International Geosphere-Biosphere Programme (IGBP), the International Human Dimensions Program, and the World Climate Research Program, START is comprised of a series of regional research networks that promote focused research and training on regional issues of global relevance, integrate and synthesize results, and provide input to national and regional decision makers.

In 1996, START distributed thirty fellowship, visiting scientist, and lectureship awards. The program assisted affiliated institutions in Africa and Asia in developing global change data and information systems. In concert with the IPCC, WCRP's CLIVAR project, the IGBP Global Change and Terrestrial Ecosystems project, and the IRI, START is building capacity for integrated assessment modeling of agriculture and food security in the Asian monsoon region and in Sub-Saharan Africa. Also, in collaboration with the IGBP, START has initiated research on changes in land use and land cover in Africa and Asia.

U.S. Country Studies Program

This program is making U.S. Global Change Research Program studies and capabilities available to other nations to help improve their understanding of climate change, strengthen their participation in the IPCC process, and assist in the development of their national communications, as called for under the FCCC.

The Country Studies Program has worked with fifty-six developing countries and countries with economies in transition around the world to estimate their greenhouse gas emissions, assess their vulnerability to climate change, evaluate their adaptation and mitigation options, and develop their climate change action plans. The program has prepared more than twenty peer-reviewed publications documenting preliminary results of this work and will be releasing several major synthesis reports and data bases in the near future. The Country Studies Program has also provided training and analytical support to more than a thousand analysts from other countries.

Sharing Observational Capabilities and Research Data

A high priority of the U.S. Global Change Research Program is to share its

climate-observing capabilities with the international scientific community and to provide easy access to global change research results and educational resources.

Integrated Global Observing Strategy

At its Plenary Meeting in November 1996, CEOS endorsed the concept of IGOS and established a team to develop a strategy for implementing the IGOS space component. The team met in February 1997 in Irvine, California, to define, characterize, and develop this component. It created the Analysis Group to examine the extent to which existing and planned missions meet defined user requirements. These activities are being coordinated actively with IGFA, with user groups, and with in situ service providers.

Global Change Research and Information Office

The U.S. supports GCRIO to provide scientists around the world access to data and information on global change research, adaptation/mitigation strategies and technologies, and global change-related educational resources. GCRIO acts as a clearinghouse for key documents and reports generated or sponsored by the U.S. government, provides high-level user services for and access to the interagency Global Change Data and Information System, and offers outreach services to both domestic and international target audiences (including governments, institutions, researchers, educators, students, and the general public).

Bilateral Cooperative Research

The U.S. Global Change Research Program is collaborating with France, Canada, and Japan--to name just a few countries--through a series of bilateral research projects.

Cooperation With France

Data from the TOPEX/Poseidon satellite mission, a U.S.-French collaborative program, challenged a fundamental oceanographic theory about the speed of large-scale ocean waves. This finding could enhance weather forecasting and capabilities for predicting the effects of El Niño events on weather patterns years in advance. The National Aeronautics and Space Administration and the French National Center for the Exploration of Space signed an agreement in December 1996 for a follow-on mission, Jason-1, to be launched in 1999.

Cooperation With Canada

Results from the BOREAS field/airborne/satellite campaign in 1996 involving the National Aeronautics and Space Administration, the National Oceanic and Atmospheric Administration, the National Science Foundation, the Environmental Protection Agency, and Canadian partners showed the air above northern forests to be drier than expected, resulting in adjustments to weather-forecasting models.

Cooperation With Japan

The United States and Japan are cooperating in many areas of global change research. The fourth in a series of bilateral Workshops on Global Change Research addressed "Land Use/Land Cover Change and Global Environmental Conservation" in February 1996 in Tsukuba, Japan. The fifth took place in March 1997 in Honolulu, Hawaii, and focused on "Improved Uses of Global Change Information."

The National Space Development Agency of Japan launched its Advanced Earth Observing Satellite (ADEOS) mission in August 1996. In addition to a French and several Japanese instruments, ADEOS carries two NASA sensors that feed back valuable information to the international scientific community. The NASA Scatterometer provides data on ocean winds and ocean-atmosphere links, and NASA's Total Ozone Mapping Spectrometer monitors global ozone and records observations of atmospheric sulfur dioxide.

Through a memorandum of understanding signed in October 1995, NASA is cooperating with the National Space Development Agency of Japan on the Tropical Rainfall Measuring Mission. Scheduled for launch in 1997, this unique mission will measure tropical precipitation globally for the first time.

The United States is also working closely with Japan in planning and developing the new Japanese Global Change Prediction Initiative. This initiative could bring substantial new resources for global change research, observations, and modeling to Japan's national program and to international efforts in these areas.

In 1995, the United States and Japan announced a plan for a Global Observations and Information Network, which will enable users in both countries to access each other's data by computer. NOAA is leading this effort, which is intended to improve connectivity and interoperability among networks for satellite and in situ observations within and between Japan and the United States.

A U.S.-Japan Joint Technical Workshop was held in June 1996 in Tokyo, and another is planned for June 1997 in Boulder, Colorado. The focus is expected to be on implementing advanced networking technologies and demonstration pilot projects. The Global Observations and Information Network is also expected to provide a model for a global information infrastructure.

Education, Training, and Outreach

Global climate change is increasingly an essential part of the context in which social, economic, and technological development takes place. Yet most U.S. citizens are unaware of this phenomenon and its impacts. Societal decision making needs to be based on an informed understanding of the factors driving global climate change, how these changes may manifest themselves, and how society can most effectively adapt to or limit future changes.

A variety of U.S. government agencies and their cross-cutting research programs are responsible for education, training, and outreach activities that inform the public and decision makers about global warming and its causes, the potential impacts on them as individuals and on society as a whole, the public role in identifying and developing solutions from an array of existing alternatives, and how to use new information in specific circumstances.

Society has a significant stake in the education and development of talented researchers who can question, analyze, and report results of investigations that enhance understanding of the natural and human dimensions of global climate change. For scientists to achieve their full potential, their interests and skills must be developed early in life. Long-term action planning and statewide strategies can foster innovative approaches to affect education at every level, integrating global change issues into statewide core curricula, professional and association meetings at regional and national levels, and programs conducted in museums, science centers, and community groups.

Several pieces of U.S. legislation have noted the need for increased formal and informal environmental education. Some of these laws are specific to global climate change education, while others are more general in scope. Some examples include the Global Change Research Act of 1990, the National Climate Program Act, the Clean Air Act Amendments of 1990, and the Environmental and Education Act of 1990.

Broad-Based Programs

It is often difficult to categorize programs as solely focused on education, training, or outreach, because most of them have some elements of each component. Following are two programs that blur the lines among the three elements, as well as a piece of legislation that likewise combines the issues.

Mission to Planet Earth

This National Aeronautics and Space Administration (NASA) program is intended to substantially improve understanding of the natural processes that govern the global environment and to assess the effects of human activities on these processes. It is expected to yield improved weather forecasts, tools for managing agriculture and forests, information for fishers and coastal planners, and, ultimately, an ability to predict how climate will change. While the program's ostensible goal is scientific understanding, its ultimate product is education in its broadest form.

One of the goals NASA created for Mission to Planet Earth is to foster the development of an informed and environmentally aware public. NASA will measure the program's success in terms of its contributions to the advancement of formal education and professional development, which provide structured opportunities for communicating the program's content to a large community.

NASA expects the program's educational resources to achieve the following objectives:

- Train the next generation of scientists to use an interdisciplinary, Earth-system science approach.
- Continue to educate and train educators as research evolves and capabilities change.
- Raise awareness of policymakers and citizens to enable prudent policy determinations regarding the global environment.
- Improve science and math literacy.
- Enhance cooperation between educators and scientists, and secure greater support by scientists for broad education efforts.
- Explore mechanisms to leverage the development of materials and products, where reasonable, to increase resource availability, expand the knowledge base, and encourage the development of an external capability, expert in translating scientific research into usable forms for a broad national audience.

To meet these objectives, Mission to Planet Earth has formulated education programs in several areas that focus on teacher preparation, curriculum support, systemic change, and student support.

Project Earthlink

Project Earthlink is an effort led chiefly by the National Oceanic and Atmospheric Administration (NOAA), the U.S. Department of Agriculture (USDA), NASA, and the U.S. Global Change Research Program. The efforts of the thirteen federal agencies involved have been complemented by the Academy for Educational Development, nonprofit organizations, White House interagency committees and organizations, nongovernmental organizations, and private industry. Following are some examples of Project Earthlink activities that have improved the public's knowledge about global change issues.

Training

In May 1994, Project Earthlink coordinated a video conference broadcast for teachers featuring scientists discussing global climate change issues. Underwritten by the Department of Education, the broadcast was received by eighty schools and various ozone depletion-oriented downlink sites across the country. More than sixteen hundred teachers were involved in the briefing and continue to network on these issues.

Education

In 1995, Project Earthlink provided scholarships for a new category of projects on global change in the International Science and Engineering Fair. This initiative reached over fifteen million students in grades 9–12 in every school district in the United States and in countries worldwide, heightening student interest in global change issues as a potential research field. This successful category was continued in 1996.

Outreach

In April 1995, Project Earthlink coordinated the American Indian Earth Day program “A Gathering for the Earth.” Indigenous people across the United States shared their diverse knowledge and beliefs regarding environmental stewardship. The live broadcast celebration reached a wide-ranging audience of students, educational TV networks, communities, libraries, museums, and federal government agencies. The program was organized around what the Native Elders referred to as the Four Directions-- Air, Water, Land and Living Beings--with segments of roundtable discussions with Elders and examples of environmentally sustainable practices. This effort exemplifies the U.S. commitment to the 1992 Rio Earth Summit Agenda 21’s component for involving indigenous people in global change discussions.

The Global Change Research Act of 1990

The Global Change Research Act of 1990 established the U.S. Global Change Research Program. This interagency collaboration among fifteen federal agencies has a multi-pronged approach to educating a diverse set of information users.

For example, the USDA Global Change Program Office publishes a monthly newsletter on current activities in the global change arena. Besides distributing print versions to a broad audience, USDA provides on-line access to the newsletter through the Internet.

To train the next generation of scientists, the U.S. Global Change Research Program supports undergraduate, graduate, and postdoctoral participation in ongoing scientific research activities. To meet the needs of formal educators, the program provides resources for statewide action planning, teacher enhancement, curriculum support, and select student support programs.

Education and Training

Global climate change education and training aims to promote understanding of the Earth system and how it is changing to ensure that societal decision making regarding climate issues is based on a thorough body of knowledge. Global change is integrated into formal education and training in many ways: teaching global issues with a focus on critical national and world problems, cutting-edge scientific research and methods with an interdisciplinary scope based on the newest technologies, and incorporation into courses for business and industry.

Global climate change education holds great potential for engaging significantly increased numbers of students in the study of science, mathematics, and geography. In global change education, the emphasis of the individual U.S. government agencies has historically been aimed broadly at the university undergraduate and graduate levels. Current programs, while continuing the focus on higher-level education, are working more comprehensively to make available educational resources at levels from kindergarten onward, not only to inspire students to undertake scientific careers but also to stimulate noncareer scientific literacy.

One way to encourage and empower students to participate in problem solving and to become comfortable with science is to engage them in authentic scientific investigation. Active participation in the ongoing investigation of Earth and the environment in a global context is applicable at differing levels of sophistication for children in elementary school through postdoctoral graduate research programs.

Efforts have also been undertaken to train the educators--especially those teaching classes from kindergarten through high school--to enable them to articulate global change-related issues and to train them in incorporating these issues into their lesson plans. Educators in both formal and informal programs identify training as critical to increasing the probability that high-quality educational materials will actually be used and global climate change concepts will be integrated into multiple disciplines at all levels of education.

Graduate and postdoctoral fellowships continue to be the major recipients of educational funding from federal agencies, contributing to the global change research and knowledge base and creating a cadre of scientists who cooperate with educators to communicate scientific information to diverse audiences. The preponderance of the U.S. climate change education focus is in this area, including a diverse array of research projects, some of which are discussed in chapter 6 of this report.

Following is a sampling of some of the current U.S. education and training-oriented programming efforts.

GLOBE

Administered by NOAA, NASA, the National Science Foundation (NSF), and the U.S. Environmental Protection Agency (EPA), Global Learning and Observations to Benefit the Environment (GLOBE) brings together students, educators, and scientists throughout the world to monitor the global environment. The program is designed to increase environmental awareness of individuals throughout the world, contribute to our scientific understanding of the Earth, and improve student achievement in science and mathematics.

GLOBE's worldwide network is comprised of students in kindergarten through twelfth grade, representing over 3,000 schools in forty-eight countries. These students

make scientific observations at or near their schools in the areas of atmosphere, hydrology, land cover/biology, and soils, and report their findings to the network.

The environmental science community is involved in the design and implementation of GLOBE to ensure that GLOBE students' environmental measurements make a significant contribution to the global environmental data base. International scientists participate in selecting GLOBE scientific measurements, developing measurement procedures, and ensuring overall quality control of data. The data acquired and the resulting global environmental images are shared among participants.

Junior Solar Sprint

This Department of Energy (DOE)-sponsored educational program teaches sixth-, seventh-, and eight-grade students theoretical and hands-on engineering skills. It encourages students to use math and science principles and their imaginations in a fun learning experience that stimulates enthusiasm for science.

The program culminates in the construction of a solar-powered vehicle model designed to complete a 20-meter (22-yard), wire-guided sprint race. Working in teams, the students are provided with kits that include a motor and a photovoltaic panel. The chassis, wheels, and transmission are made from materials of the students' choosing.

Begun in 1990 as a pilot program, by 1996 Junior Solar Sprint had expanded to eighty-three host sites in twenty-six states, involving 100,000 students and 15,000 teachers.

Global Change Teacher Packet

The Department of the Interior's U.S. Geological Survey has produced 20,000 copies of the Global Change Teacher Packet, with a poster and set of classroom activities. These multimedia materials include modules on the greenhouse effect, geologic time and environmental changes, and the carbon cycle. The teaching packet was subsequently reformatted for Internet distribution. A new multimedia CD-ROM, "GeoMedia2," was also created, incorporating global change topics.

SEED at ORISE

The Science/Engineering Education Division (SEED) at the Oak Ridge Institute for Science and Education (ORISE) develops and administers collaborative research appointments, graduate and postgraduate fellowships, scholarships, and other programs that capitalize on the resources of federal facilities across the nation and the national academic community. The aim is to enhance the quality of scientific and technical education and literacy, thereby increasing the number of graduates in science and engineering fields, particularly those related to energy and the environment.

The Global Change Education Resource Guide

Produced by NOAA, the Global Change Education Resource Guide is a multimedia set of materials with videotape, CD-ROM, full-color overhead transparencies/slides with scripts, IUCC/World Meteorological Organization fact sheets, articles for general audiences, classroom activities, and a resource bibliography. Topics include natural variability, the greenhouse effect, sea level rise, ozone depletion, ecosystem response, and decision making under scientific uncertainty.

An example of an interagency collaboration, EPA, DOE, NASA, USDA, the Department of Defense (DoD), and the Department of State (DOS) printed 26,500 copies of the Resource Guide and distributed them directly to formal and informal educators nationwide. These copies were duplicated for further distribution at education workshops on global change held throughout the country.

Global Change Education Program

The DOE Global Change Education Program has three coordinated components aimed at providing both research and educational support to postdoctoral scientists, to graduate students, and to faculty and undergraduates at minority colleges and universities. One-third of postdoctoral fellows serve their appointments at NASA, NOAA, NSF, and USDA laboratories.

Once every two years, the program sponsors a workshop to provide a forum for current fellows to begin the interdisciplinary networking that is necessary for integrating and assessing their results and addressing global change policy issues. Graduate fellows must spend at least six weeks at DOE or other Committee on the Environment and Natural Resources laboratories to acquaint themselves with ongoing multidisciplinary research programs in global change. Annual reporting of research occurs at national meetings organized for recipients. Summaries of research results are published in a compendium.

The Sea Grant Program

NOAA developed and supported complementary teacher training programs for in-service education in the form of a four-year national train-the-trainers effort for informal educators through the Sea Grant College Program. Over 15,000 educators have benefited from this program and its ancillary activities, such as workshops for teachers and students, newsletters, presentations at professional meetings, articles in professional journals, and community outreach.

DoD promoted education of minority teachers and teachers of minority students through Operation Pathfinder. The program's focus is the potential impacts of global climate change on marine ecosystems. The program is conducted jointly throughout the

NOAA Sea Grant Education Program in the coastal and Great Lakes regions of the United States.

NSF supports teacher training in global change through grants for national and regional programs. For example, a four-year Gulf–South Atlantic global change teacher education project was conducted through the Mississippi–Alabama Sea Grant consortium.

Project NOVA

Pre-service education has been identified as an approach to train emerging teachers earning degrees in education from colleges and universities. NASA's Project NOVA is an example of providing support to university teams (from Education and Science Departments) to develop courses and/or course modules for students seeking teacher certification. Currently, a NASA proposal solicitation for Pre-Service Teacher Enhancement seeks to conduct workshops for students of education that will provide exposure to Earth system science and training/access to available curriculum support materials.

Public Outreach

Outreach is a crucial component of global change education, and is the area that can reach the largest number of individuals. The U.S. government is directly involved in a variety of public outreach efforts, and is indirectly involved through state and local outreach programs.

Outreach activities include programs in museums, science centers, nature centers, youth programs, adult continuing education, and displays in shopping malls and other public places. Programming in this area ranges from lectures to multimedia presentations.

Multimedia communication resources provide a valuable mechanism for communicating the complex, interdisciplinary nature of global change research. Federal agencies have historically contributed resources and materials on global change and will continue to do so.

State and local governments are targeted for global change outreach because they have regulatory authority over many direct and indirect sources of greenhouse gas emissions. For example, local governments define land use, zoning, transportation, and procurement policy; operate landfills; monitor air quality; pass and enforce building codes; and regulate parking. Outreach programs can assist state and local governments in analyzing their options and determining the environmental and economic impacts of mitigation policies on their region.

EPA and DOE have taken leading roles in coordinating public–private partnerships through a wide variety of programs generated by the U.S. Climate Change Action Plan, which was signed by President Clinton in 1993. In addition, the United States has

established a White House Climate Change Task Force to coordinate and expand activities among agencies aimed at informing the public and interested parties about climate change, especially the Administration's policy and international negotiating positions.

Finally, Internet sites are rapidly being identified as a cost-effective way for U.S. government agencies and others to conduct outreach efforts and to facilitate the dissemination of information on global climate change and other subjects to the widest possible range of interested parties both in the United States and worldwide. Many U.S. government agencies already have Internet sites on the World Wide Web, and it is becoming more common for global change segments to be featured on agency-sponsored or -supported sites. A vast array of information and scientific data is available from U.S. government agencies, programs supported by U.S. government funding, nongovernmental organizations, and an enormous number of other interested parties. Some of these programs are described in this section.

National Park Service's Olympic Exhibit

The Department of the Interior's National Park Service developed an exhibit about global sustainability issues to educate visitors to the 1996 Olympic Games in Atlanta, Georgia. An accompanying six-minute video illustrated case studies using renewable technologies, sustainable design, and collaborative approaches.

Reporting on Climate Change: Understanding the Science

Produced and published by the nonprofit National Safety Council's Environmental Health Center (EHC), and supported by NOAA, Reporting on Climate Change: Understanding the Science is one of a series of reporter's guides designed to enhance public understanding of the significant environmental health risks and challenges facing modern society (NSC 1994).

This reporter's guide deals exclusively with elements related to global change and contains both subject-specific chapters that explain particular issues in detail, as well as more general chapters focused on strategies for successful science reporting, interaction with the scientific community, and understanding scientific reporting methods and nuances. It contains a glossary and list of sources of additional information (environmental, industry, governmental, international, etc.).

Since the guide's publication in 1994, more than 10,000 copies have been distributed to journalists. In March 1995, 1,000 copies of the guide were distributed to the working press at the Berlin Conference of the Parties to the Climate Convention to facilitate the media's comprehension of the scientific and technical issues being discussed.

DOD Initiatives

President Clinton signed an Executive Order in February 1995, directing the declassification of imagery obtained by the first generation of photo-reconnaissance satellites. More than 800,000 satellite images collected between 1960 and 1972 are designated for declassification under this order. The public will be able to access these records through the National Archives facility at College Park, Maryland.

DOE Regional Roundtables

After the signing of the Climate Change Action Plan in the fall of 1993, in the spring of 1994 DOE held roundtable meetings with various segments of the energy industry to discuss implementation of DOE's planned energy partnership programs. Workshop participants were asked to advise DOE's Office of Energy Efficiency and Renewable Energy about how to improve the quality of the individual program implementation plans, as well as the overall package of initiatives. Attendees represented a diverse group of interests, including manufacturers, builders, utility executives, and engineers, and offered a variety of perspectives on the programs. These meetings were instrumental in shaping the final energy partnership programs, and many of the participants' suggestions were incorporated into the revisions.

IREC's PARK POWER

With the support of DOE, EPA, and others, the Interstate Renewable Energy Council (IREC) created a program entitled PARK POWER: Using Solar Energy for Public Spaces. Initially, IREC distributed an EPA-funded procurement guidebook entitled Procurement Guide for Renewable Energy Systems: A Guidebook for State and Local Government Agencies, and held one-time workshops with state and municipal parks departments. This procurement guidebook is the foundation of IREC's "workshop in a box" series, which represents an effort to develop techniques and strategies to make state-based renewable-energy procurement activities more effective (IREC 1993).

The first efforts were targeted at state and municipal parks departments and were based on the successes with renewable-energy systems in U.S. national parks. Recent efforts have been tailored to meet the needs of individual parks department staffs in order to reach IREC's goal of routine purchases of renewable-energy systems by procurement officials.

EPA's State and Local Climate Change Program

This EPA program provides outreach assistance, including training workshops and reference manuals, preparing greenhouse gas emissions reports, developing comprehensive greenhouse gas reduction plans, testing innovative policies, disseminating results, providing education and outreach materials, and examining regional impacts of mitigation policies. The program is a catalyst that enables decision makers to understand and act on the risks associated with global warming.

Among the strategies identified in the state mitigation plans are: emission caps and trades, energy-efficient mortgages, revised building codes, incentives for purchasing fuel-efficient vehicles, afforestation, and partnership programs.

At the local level, the program is working in partnership with the International Council for Local Environmental Initiatives (ICLEI) to assist cities and counties through two ICLEI programs.

- Green Fleets focuses on transportation energy use and the development of integrated measures to reduce local demand for travel.
- Cities for Climate Protection Campaign engages municipalities in climate change abatement policy. The campaign strengthens local commitments to reduce greenhouse gas emissions, develops and disseminates tools to increase local capacity, and encourages energy-efficient practices.

Ocean Planet

On Earth Day, April 22, 1995, the Ocean Planet exhibit opened at the National Museum of Natural History, in Washington, D.C. Organized by the museum and the Smithsonian Institution's Environmental Awareness Program, the exhibit promotes the celebration, understanding, and conservation of the world's oceans, and includes a component on the impacts of climate change. During the year it appeared at the Museum of Natural History, Ocean Planet attracted nearly two million visitors. After April 1996 it was converted into a traveling exhibit, and will continue traveling nationwide until 1998.

A World Wide Web site was set up in May 1995, for individuals who cannot see the exhibition or who wish to have additional information. Visitors to the Internet site can "walk through" the exhibit, as well as view programs and materials for educators, and learn about exhibit-related events and other activities. It is anticipated that millions of people around the world will view the exhibition itself, the web site, articles, advertising inserts, and electronic media coverage during Ocean Planet's tour.

ENERGY STAR[®]

The outreach components of ENERGY STAR[®] programs raise the level of public consciousness regarding climate change in concrete, easily understandable, and relevant everyday terms. Following are some highlights of ENERGY STAR programs. Chapter 4 of this communication presents other aspects of ENERGY STAR programs in greater detail.

- *ENERGY STAR Billing Program*--EPA works with interested utilities to enhance their billing formats with customer feedback information designed to motivate homeowners to decrease their energy use and to pursue cost-effective, energy-efficient upgrades.

- *ENERGY STAR Buildings*--ENERGY STAR commercial and industrial buildings account for over 15 percent of all U.S. energy consumption. Through this voluntary partnership program, EPA works with individual building owners, developers, and others to encourage more comprehensive building upgrades. The program leads building owners through a five-stage strategy to capitalize on system interactions that maximize energy savings at minimum cost and prevent pollution.
- *ENERGY STAR Homes and Financing Programs*--EPA is creating partnerships with home builders to significantly reduce the high cost of residential energy use. EPA provides guidance on how to build more energy-efficient homes and maintain the designs preferred in the housing market. Qualified builders are encouraged to use the ENERGY STAR logo and to offer home buyers access to the ENERGY STAR financing programs available for buyers of these homes to help minimize initial home investment costs.
- *ENERGY STAR Office Equipment*--Through this program, EPA is working with manufacturers to develop office products that use less energy, is educating consumers on the benefits of energy-efficient office equipment, and is encouraging organizations to purchase only energy-efficient office equipment and to reduce paper use.
- *ENERGY STAR Product Labels*--EPA and DOE are using the ENERGY STAR label to identify products and services that save energy, save money, and help the environment. The goal of the ENERGY STAR labeling program is to provide consumers with clear information they need about energy-efficient products to make enlightened purchasing decisions.
- *ENERGY STAR Transformers*--Traditionally transformers have been a source of significant energy losses. EPA is working with utilities to increase the efficiency and cost-effectiveness with which power is converted from the high voltage used in transmitting electricity to the lower voltage used in homes and businesses, and thus to encourage purchases of high-efficiency transformers.

Global Climate Change Internet Sites Sponsored or Supported by the U.S. Government

<http://www.epa.gov/globalwarming>--This EPA-sponsored site contains information about global warming; the latest developments in the field (conferences, research, and solutions); the projected impacts of global warming; international and U.S. government policies and programs; opportunities for individuals, states, localities, and businesses to reduce the impacts of global warming; and easy ways to obtain more information.

<http://www.hq.nasa.gov/office/mtpe>--The Mission to Planet Earth (MTPE) site includes data concerning MTPE programs, projects, and priorities, as well as information about NASA Headquarters and Field Centers, which both participate in

developing MPTE's sustainable education strategy and conduct MTPE educational programs.

<http://www.usgcrp.gov>--The U.S. Global Change Research Program site features information regarding USGCRP-sponsored and -related programs and web site links, as well as educational resources.

<http://www.eren.doe.gov>--Sponsored by DOE for the Energy Efficiency and Renewable Energy Network (EREN), this site provides information on energy-efficiency events, initiatives, and activities; includes a listing of clean-energy web sites; and contains information targeted for students working on science projects regarding energy-efficiency and renewable-energy issues. It also answers energy-related questions submitted via e-mail.

<http://www.state.gov/www/global/oes/envir.html>--The U.S. Department of State's Bureau of Oceans and International Environmental and Scientific Affairs sponsors this site, which contains foreign policy-related information regarding climate change, including speeches on relevant issues.

<http://www.globe.gov>--This web site provides information about the Global Learning and Observations to Benefit the Environment program and contains categories of interest to prospective visitors (students, scientists, parents, etc.) to the site. Each day, images from the GLOBE student data sets are posted on the site, allowing students and visitors to visualize the student environmental observations.

<http://www.ji.org>--This web site is designed to be an on-line resource for news and information about worldwide Joint Implementation activities. It includes official information from the United States Initiative on Joint Implementation, other government programs that support these activities, and information on private-sector projects to reduce or sequester greenhouse gas emissions.

<http://cdiac.esd.ornl.gov>--The Carbon Dioxide Information Analysis Center helps international researchers, policymakers, and educators evaluate complex environmental issues, including potential climate change, associated with elevated levels of atmospheric carbon dioxide and other radioactively active trace gases. The Center is funded through a grant from DOE.

<http://www.gcric.org/csp/webpage.html>--This web site contains information about the U.S. Country Studies Program, which is assisting fifty-five developing countries and countries with economies in transition in conducting climate change studies. The page includes program information and history, detailed information on each of the studies, workshop information, lists of contacts, and technical information resources.

<http://www.weea.org/worldwide>--The World Energy Efficiency Association maintains this site, with assistance from the U.S. Agency for International Development. The site is a full-text technical library of approximately thirty documents relating to energy efficiency.

<http://www.wri.org/climate>--The World Resources Institute web site features educational materials on global environment and development issues. WRI disseminates those materials through networks and workshops, works internationally with educational organizations to adapt these materials for use abroad, and partners with U.S. educational organizations to promote and incorporate environmental education into mainstream U.S. education.

<http://www.ciesin.org>--The Consortium for International Earth Science Information Network site contains a variety of information, including interactive applications, metadata and data resources, information systems and resources, and programs, such as the Global Change Research Information Office.

<http://www.crest.org>--The Center for Renewable Energy and Sustainable Technology's site contains information on sustainable energy and development. It includes listings of related data bases, web sites, relevant documents, mailing lists, sustainable energy software, and environmental education and workshop information.

http://seawifs.gsfc.nasa.gov/ocean_planet.html--The Smithsonian's Ocean Planet exhibit is presented on the Internet for people unable to attend the traveling exhibit or who may want additional information. Site visitors can take a virtual tour of the exhibit, use on-line educational materials, view information about special events, see listings of related publications, and select from other options.

Future Directions--The President's Council on Sustainable Development

Established in 1993, the President's Council on Sustainable Development (PCSD) is comprised of thirty-five leaders from industry, all levels of government, and diverse nongovernmental organizations. The Council's 1996 report *Sustainable America: A New Consensus for Prosperity, Opportunity and a Healthy Environment for the Future* articulated ten goals related to health and environment, economic prosperity, equity, conservation of nature, stewardship, sustainable communities, civic engagement, population, international responsibility, and education (EOP/CSD 1996b).

Education is a primary vehicle to help individuals and decision makers make informed choices that advance sustainable development. Recommendations for implementing the Council's education policy are presented in *Education for Sustainability: An Agenda for Action*, a two-year collaborative effort among hundreds of leaders across the nation representing government, business, nongovernmental organizations, and educational communities (EOP/CSD 1996a). The Agenda outlines potential projects, programs, and opportunities that will encourage education for sustainability as a critical part of a lifelong learning process.

PCSD established the Education for Sustainability Working Group (EWG) to support partnerships among the education and extension networks, government, and the private sector. The EWG will provide national and international leadership that supports collaborative partnerships between the public and private sectors, interagency cooperation, federal policies, and coordination and implementation of education for sustainability programs.

The EWG will report on the status and future of education for sustainability, provide technical assistance to education leaders, manage a federal interagency working group, promote linkages with PCSD task forces and working groups, and coordinate education outreach efforts. It will communicate a consistent message that supports

education for sustainability and advances the Administration's commitment to a healthy environment, world-class education, and a prosperous economy. Following are some descriptions of EWG initiatives.

Business Forum for Sustainable Development

The business community has an expressed interest in our nation's educational system, since the students of today are the work force of tomorrow. Business brings a number of resources to the table, from financial support to technical skills to research.

Business can support education for sustainability through mentoring programs, internships, and school-to-work opportunities. It can bring professionals into classrooms as guest teachers and students into the business environment to observe how employees tackle real-world problems. A business forum can advance education for sustainability by bringing together diverse businesses to train employees, shift production processes, educate communities about sustainable business practices, and participate in curriculum development activities with professional societies and graduate schools.

National Sustainable Development Extension Network

A national Sustainable Development Extension Network will build on existing federal extension services, such as USDA's Cooperative Extension System, NOAA's Sea Grant Marine Advisory Service, the Department of Commerce's Manufacturing Extension Partnership, NASA's Space Grant Program, and the Small Business Administration's Small Business Development Centers. By using existing infrastructure, coordinating national policy and programs, and responding to community needs related to sustainability, this national network will help meet the education, training, information, and technology transfer needs of communities, states, and regions in planning sustainable courses of action.

School Construction Initiative

The extensive renovation and new construction taking place across the country present an opportunity to promote energy efficiency and pollution reduction in the nation's schools.

The EWG will continue to work with EPA to investigate the possibilities for regulatory streamlining incentives for schools to provide superior environmental performance. The EWG and EPA will also explore the possibilities for granting tradable emission-reduction credits for community initiatives in land-use planning.

The EWG is also working with DOE to determine how its "conservation protocol"-- which sets a performance-based standard for energy efficiency in public buildings--might be used to leverage financing. This program also provides an opportunity for a comprehensive education program associated with this initiative. Based upon

building design, pollution reduction, waste stream management, community decision making, and a multidisciplinary curriculum on sustainability, this initiative will provide a local, relevant focus on complex issues faced by individuals, organizations, and communities.

State Capacity Building

Building state capacity to integrate concepts of sustainability into existing formal and informal education programs and lifelong learning opportunities is essential to developing national literacy in education for sustainability. NASA, EPA, and USDA support a public–private education partnership that has created capacity among fifty state teams. This partnership continues to devise innovative ways to provide resources and expertise to states for capacity building, curriculum enhancement, public–private partnerships, and professional development. Federal agencies will work collaboratively with state teams organized through this initiative and through private-sector partners, such as the National Environmental Education Advancement Project.

International Program

As a follow-up to U.S. leadership during the United Nations Commission on Sustainable Development in April 1996, the EWG and the State Department will work with UNESCO to develop the Work Program the Commission requested at that time. The State Department is leading an effort to develop and maintain an Internet-based international data base of education for sustainability resources and programs.

The sheer size and diversity of the United States necessitates a variety of education, training, and outreach programs that support education for sustainability and are coordinated and supported at the federal level. However, to ensure their local relevance, these programs should be carried out at the state and local levels. A number of federal agencies with regional offices throughout the country (e.g., EPA, USDA, and the U.S. Army Corps of Engineers) could facilitate the dissemination of sustainability information.

Throughout 1997 various government agencies are hosting numerous climate change outreach events across the country, such as “town hall” formats, science-oriented regional workshops, and debates. These events are designed to enhance public comprehension of global change issues and to help citizens envision how climate change may affect their communities.

International Activities

Global problems demand global responses. While the efforts of each individual country to control its own greenhouse gas emissions are important, it is clear that no single country or even group of countries can alone eliminate the threat of climate change.

So far, the international community has responded energetically, gathering ever more accurate scientific data, striving to achieve the goals set forth in the Framework Convention on Climate Change, and beginning negotiations toward new commitments for the post-2000 period. The United States has played a leading role in these efforts by actively participating in the Intergovernmental Panel on Climate Change, the Climate Convention's Ad Hoc Group on the Berlin Mandate, and the Global Environment Facility. The United States has also used its influence in other multilateral fora--notably, the multilateral development banks, the Organization for Economic Cooperation and Development (OECD), and the International Energy Agency (IEA)--to place the climate change issue squarely on the agenda and to foster policies that can help to mitigate climate change.

Perhaps the greatest opportunity for cooperation lies in the assistance developed countries can provide to developing countries and countries with economies in transition. Although developed countries have historically had the highest greenhouse gas emissions, the emissions of other countries are growing rapidly and will most likely surpass those of developed countries during the first few decades of the twenty-first century.

Effectively addressing global climate issues will require a strong commitment from developed nations to help developing countries limit their greenhouse gas emissions. Accordingly, the United States has included climate change-related projects in its foreign assistance effort. Many of these projects directly help to limit current emissions, while others build the institutional capacity to address future emissions. Because these activities most likely will not be undertaken in the absence of U.S. aid, they represent an important aspect of the total U.S. response strategy described in this communication.

U.S. climate change projects are based on the core principles of the U.S. development assistance strategy. These principles support economic growth and social development that:

- Protect the resources of the host country.
- Respect and safeguard the country's economic, cultural, and natural environments.
- Support the design and implementation of favorable policy and institutional frameworks for sustainable development.
- Build indigenous institutions that involve and empower the citizenry.

This chapter begins with summaries of the many programs implemented bilaterally, and ends with descriptions of the broad spectrum of multilateral organizations that have undertaken climate change activities.

Bilateral Technical Assistance and Technology Transfer

In defining its climate change strategy for bilateral assistance, the United States decided to focus on mitigation rather than adaptation. Thus, the purpose of most of the projects described here is to reduce greenhouse gas emissions or sequester greenhouse gases. In many cases, projects combine elements of mitigation with information sharing, technology transfer, and trade facilitation. Generally speaking, the mitigation projects described in this chapter include efforts in the following categories, although an individual project may incorporate more than one of these areas:

- *Energy Demand.* Reduce end-user energy demand through conservation and energy efficiency, resulting in reduced fuel consumption and greenhouse gas emissions.
- *Energy Generation.* Increase the efficiency of power generation. Use clean-coal technology to achieve significant immediate greenhouse gas emissions in countries where coal is widely used.
- *Energy Distribution.* Reduce losses in transmission and distribution processes, especially in rural networks, thus effectively increasing capacity without additional fuel consumption.
- *Renewable Energy.* Encourage the adoption of renewable-energy technologies, particularly in rural areas, to replace fossil fuels or to increase capacity without increasing fossil fuel consumption.
- *Energy Restructuring.* Support power-sector restructuring, on the assumption that the private sector generally makes more rational use of energy resources than do government-owned or -subsidized monopolies. Open existing power-grid systems to sales from independent power producers.
- *Regulatory and Policy Reform.* Support regulatory reform practices for the electric power sector, including tariff reform. Encourage policies to promote investment in clean technology.
- *Clean Air.* Reduce air pollution, with the ancillary environmental benefit of reduced greenhouse gas emissions.
- *Methane Reduction.* Reduce methane emissions through coalbed methane recovery, landfill methane recovery, reduced flaring of natural gas, and other methods, and provide an additional clean-burning fuel source with low greenhouse gas emissions.
- *Forestry Projects.* Enhance carbon sinks through forestry projects that reduce deforestation or that support reforestation or afforestation of degraded lands.
- *Agricultural Management.* Improve agricultural and livestock practices to reduce emissions of nitrogen from pesticide applications and methane from ruminant animal husbandry.

U.S. bilateral assistance is conducted primarily through the U.S. Agency for International Development (USAID). Several other U.S. government departments and agencies are involved in climate change issues as well--notably, the Department of Energy (DOE), the Environmental Protection Agency (EPA) and the Department of Agriculture (USDA). Partnerships among various government agencies, nongovernmental organizations, private industry, and international organizations characterize many of these projects.

USAID has made the mitigation of climate change one of two global environmental priorities. It has identified nine key climate change countries (Mexico, Brazil, India, Indonesia, the Philippines, Russia, Ukraine, Poland, Kazakstan) and one key region (Central Africa) in which it works that are, or will become, significant contributors to global greenhouse gas emissions. USAID is forming partnerships to enable these countries to reduce the growth of net greenhouse gas emissions through approaches that also contribute to economic growth and local environmental protection.

In addition to these specific programs, USAID's broader portfolio of energy-efficiency, renewable-energy, and forestry activities contributes to mitigation and sequestration efforts in other countries, while other programs build capacity for countries to adapt to the adverse effects of changing climates.

U.S. Country Studies Program

The Framework Convention on Climate Change (FCCC) requires all signatory countries to provide to the Convention Parties a national inventory of greenhouse gas emissions by sources and removals by sinks, and to describe the steps they are taking to implement the Convention, including adaptation and mitigation measures. To help developing countries and countries with economies in transition (the New Independent States and Eastern Europe) meet this commitment, and to fulfill in part its own obligations under the Convention to provide additional financial resources to developing countries, the United States initiated the Country Studies Program (CSP) in 1992.

The primary objectives of the CSP are to:

- Enhance the abilities of countries and regions to inventory their greenhouse gas emissions, assess their vulnerabilities to climate change, and evaluate strategies for mitigating emissions and adapting to the potential impacts of climate change.
- Enable countries to establish a process for developing and implementing policies and measures to mitigate and adapt to climate change, and for reexamining these policies and measures periodically.
- Assist countries in preparing climate change action plans that may form the basis for their national communications.

- Promote diffusion of mitigation and adaptation technologies by assisting countries with assessments of needs and opportunities for technology exchange and diffusion.
- Develop information that can be used to further regional, national, and international discussions of climate change issues and increase support for the Climate Convention.

Ten U.S. government agencies have pooled their resources to implement the CSP. A Country Studies Management Team, with full-time personnel drawn from the Environmental Protection Agency, Department of Energy, Agency for International Development, Department of State, and Department of Commerce/National Oceanic and Atmospheric Administration conducts the day-to-day operations and oversees projects in conjunction with individual U.S. agency project officers.

The CSP complements global climate change mitigation and sequestration activities implemented by other agencies, such as USAID and multilateral donors (e.g., the United Nations Development Program, the United Nations Environment Program, the Global Environment Facility, and individual OECD countries). The United States coordinates financial and technical support activities with other donors through several venues, including the CC:FORUM project of the FCCC Secretariat.

Progress Toward Completing Country Studies

The CSP is currently helping fifty-five countries build the human and institutional capacities necessary to assess their vulnerability to climate change and opportunities to mitigate it. Most of the countries have completed major elements of their country studies and have disseminated their results to the international community. The CSP has issued three major synthesis reports that document the results of these studies:

- Interim Report on Climate Change Country Studies, March 1995 (contains preliminary results from twenty-one countries).
- Greenhouse Gas Emission Inventories: Interim Results from the U.S. Country Studies Program, May 1996 (contains inventory results from twenty-four countries).
- Vulnerability and Adaptation to Climate Change: Interim Results from the U.S. Country Studies Program, May 1996 (contains vulnerability and adaptation assessment results from thirteen countries).

The CSP plans to publish a synthesis report on mitigation assessment in 1997.

To give countries an opportunity to share their results and learn from each other's experiences, the CSP has co-sponsored several regional and global workshops with other countries and international institutions. The published proceedings document the country results, methods, and common assessment issues. The program's synthesis reports and handbooks on climate change assessment methods and steps in preparing climate change

action plans have also made important contributions to the work of the Global Environment Facility, the Intergovernmental Panel on Climate Change, and the Subsidiary Bodies to the Convention and other international organizations.

Next Phase: Support for National Action Plans

At the first Conference of the Parties, the United States announced the next phase of the CSP--Support for National Action Plans (SNAP). During 1995 and 1996, the CSP began assisting eighteen countries with preparing their national action plans. Most of these countries have established specific priorities for mitigation and adaptation measures and are currently working with U.S. and international experts on developing their measures and implementation plans.

More than twenty-five additional countries have requested assistance from the CSP for preparing their action plans. In 1997 and 1998, the CSP will complete its technical support to the original eighteen countries and will initiate support for a number of new countries. Other goals for these two years include assisting with the design and financing of technology projects, preparing reports for the Third and Fourth Conferences of the Parties on the progress and achievements of the program, and convening further workshops that highlight country commitments in their action plans, technology transfer, and financing successes.

U.S. Initiative on Joint Implementation

Article 4.2(a) of the Framework Convention on Climate Change provides for Parties to meet their obligation to reduce greenhouse gas emissions jointly with other Parties. Thus, joint implementation refers to cooperative efforts among countries or entities to meet this goal. In April 1995, the first Conference of the Parties to the FCCC further advanced this concept by initiating an international pilot phase, called Activities Implemented Jointly.

The United States announced the U.S. Initiative on Joint Implementation (USII) pilot program in October 1993 as part of the U.S. Climate Change Action Plan. To date, the USII has accepted twenty-five projects in eleven countries that apply a diverse set of energy-related and land-use technologies and practices. Chapter 4 of this report describes USII in greater detail.

Worldwide Projects

Some of the U.S. development assistance programs related to climate change have partners around the world. Most programs are in the areas of sustainable energy or land use. The funding figures provided for each project represent only those expenditures that have been obligated by the date of this report's publication.

Energy Efficiency Project

EEP mitigates greenhouse gas emissions by introducing to the power and commercial sectors environmentally sound, energy-efficient technologies and by promoting related policy reforms, investment incentives, and energy management and planning tools. Specifically, EEP helps host countries design and implement innovative demand-side management projects and pilot programs, address energy-sector policy and institutional reform issues, promote private-sector involvement in energy efficiency, expand U.S. technology transfer, and promote energy information dissemination through outreach and training. EEP works cooperatively with universities, research centers, trade associations, and nongovernmental organizations (NGOs) both inside the United States and in developing countries and countries with economies in transition.

EEP emphasizes three strategic elements: (1) building institutional partnerships, (2) promoting technology cooperation between U.S. and in-country firms, and (3) leveraging financing for energy-efficiency projects. To build local capacity, which is critical to sustaining development efforts, all EEP activities involving specific countries have an institutional counterpart to assist in carrying out the project's objectives. On the technology front, EEP promotes innovative, market-driven technology cooperation between U.S. and developing country organizations. In the financing arena, EEP leverages funding from private and multilateral development banks by providing initial design and start-up efforts that will lead to projects being funded by these institutions.

- *USAID, \$34 million, 1992-2002, Worldwide*

Energy Technology Innovation Project

ETIP introduces innovative and environmentally sound technologies and management techniques that promote efficient, sustainable, and cost-effective electricity generation, transmission, and distribution in developing countries. The project focuses on reducing greenhouse gas emissions from power-generation and landfill facilities, as well as from the transportation sector.

ETIP has supported such activities as a clean-coal technology mission, technology transfer to the Energy Authority in Thailand to reduce atmospheric emissions at its Mae Moh power station, and an engineering assessment for the Philippines National Power Corporation on the rehabilitation of existing power-generation facilities. In Mexico, ETIP has brokered a successful cost-sharing arrangement between a U.S.-based municipal utility and a highly polluting power station to reduce smokestack emissions and increase burner efficiency.

- *USAID, \$20 million, 1990-2002, Worldwide*

Energy Training Project

The ETP provides a unique opportunity for qualified energy and environmental professionals and policymakers from developing countries to receive hands-on training in the United States or in the host country. The resulting increase in local institutional capacity to resolve energy-sector problems has led to improvements in energy efficiency,

increased deployment of renewable-energy technologies, and more effective management of utilities and energy resources, while increasing the potential for economic growth.

U.S.-based courses are designed to provide mid-level engineers, planners, and other specialists with the skills needed to implement new technologies, policies, or procedures. In-country courses are custom-designed to provide senior-level policymakers and executives with the information they need to make informed decisions on new energy and environmental technologies, policies, and procedures. A study tour program brings senior-level energy-sector professionals to the United States to observe new energy technologies, policies, and procedures in action. Over four thousand developing country professionals have participated in the ETP.

In addition, the ETP's Utility Partnership Program has initiated successful twinning relationships between senior technical U.S. and in-country utility staff in ten countries worldwide.

- *USAID, \$37 million, 1987-1999, Worldwide*

Renewable Energy Applications and Training

The REAT program funds global, regional, and country-specific activities to increase the commercialization of renewable-energy technologies. It focuses on removing obstacles to the use of commercially proven technologies that use wind, solar, biomass, small hydro, and geothermal resources. REAT emphasizes information and skills transfer, policy reform, private-sector involvement, project identification and design, and identification of financing mechanisms.

Focus countries/regions for REAT include the Philippines, Indonesia, India, Central America, Brazil, Mexico, and Southern Africa. USAID is funding in-country Renewable Energy Project Support Offices in the Philippines, Indonesia, India, Central America, and Brazil. These offices provide technical and financial assistance to help identify and evaluate renewable-energy projects.

- *USAID, \$34.3 million, 1985-2002, Worldwide*

Biomass Energy Systems and Technology

BEST reduces the technical, financial, economic, and institutional risks associated with biomass energy systems so that public- and private-sector interests (both U.S. and indigenous) will invest in commercially proven energy-conversion systems in target countries. The BEST project has been dedicated to promoting the use of certain biomass fuels (namely, crops and crop residues) to reduce greenhouse gas emissions. For example, biogas technologies can be used to increase the efficiency of energy production, while cogeneration technologies can turn biomass waste products into energy.

- *USAID, \$15 million, 1989-1996, Worldwide*

Private-Sector Energy Development Project

PSED promotes the private ownership, financing, and operation of electric-power facilities in selected developing countries. Because private power developers operate more efficiently than government-owned and -subsidized utilities, their operations consume less fuel to satisfy current demand levels, thus reducing greenhouse gas emissions. In fact, opening existing power-grid systems to sales from private producers is often the most effective incentive for developing unconventional renewable-energy resources.

PSED originally concentrated on familiarizing U.S. companies and foreign governments with the benefits and opportunities of private power-sector development. Current PSED activities include helping private power companies develop and implement environmentally acceptable, economically sound power-generation technologies. About 70 percent of the projects approved under the PSED Feasibility Study Fund use alternative or renewable fuels.

- *USAID, \$18 million, 1989-1999, Worldwide*

Committee on Energy Efficiency Commerce and Trade

COEECT is an interagency project that facilitates the export of U.S. energy-efficient products and services worldwide by bringing together potential foreign customers and decision makers, funding sources, and U.S. industry.

- *14 U.S. agencies, \$3.1 million, 1993-1996, Worldwide*

Committee on Renewable Energy Commerce and Trade

CORECT is an interagency working group whose primary objective is to forge an effective partnership between the U.S. private sector and the federal government to mobilize the resources of CORECT member agencies and help the renewable-energy industry find foreign customers.

Each market presents barriers to the transfer of these technologies, such as unfamiliarity with the capabilities of renewable-energy technology, lack of renewable-energy resource data, difficulties in obtaining financing, and regulations impeding the establishment of private power operations that use renewable sources of energy. CORECT works with industry to determine where it is unable to overcome these barriers without specialized assistance from the U.S. government. CORECT also seeks to identify sources of lending that emphasize commercial, rather than federal, financing.

- *14 U.S. agencies, \$5.7 million, 1994-1996, Worldwide*

Forestry Support Program II

This project aims to ensure a sustainable forest and natural resource base in developing countries. It promotes the contribution of trees to sustainable development and strengthens the capacity of institutions that manage forestry and natural resources in

developing countries. It also provides technical assistance and training, private enterprise development, and facilitation of donor collaboration.

- *USAID, USDA, and Peace Corps, \$25 million, 1991-1999, Worldwide*

Ruminant Livestock Methane Reduction Projects

EPA has conducted ruminant livestock studies in several countries, including India, China, Bangladesh, Nepal, Brazil, Ukraine, Tanzania, and Zimbabwe. The studies focus on cost-effective opportunities for improving the diets and productivity of large ruminant animals, and simultaneously reducing methane emissions per unit of meat or milk produced.

- *EPA, \$300,000, 1991-1997, Worldwide*

International Fund for Renewable Energy and Energy Efficiency

IFREE uses in-country experts to foster sustainable-energy projects in emerging markets and to facilitate partnerships between U.S. and foreign energy companies. For qualifying projects, IFREE loans up to \$50,000 to share the cost of preinvestment work, and acts as a broker to financial institutions.

- *EPA, USAID, and DOE, \$5 million, 1993-1997, Worldwide*

Transfer of Voluntary Programs

EPA has awarded a grant to the International Institute for Energy Conservation to explore opportunities for transferring to Asian, Latin American, and Central and Eastern European countries the approaches of selected U.S. voluntary programs, including ENERGY STAR[®] and Green Lights. This effort will identify similarities and differences between the energy-use patterns of these countries and those of the United States, as well as the types of incentives for assisting and the barriers that may hinder different voluntary program approaches.

- *EPA, \$1.55 million, 1995-1996, Worldwide*

Regional Projects

As a component of the U.S. contribution to the international Climate Technology Initiative announced by OECD countries in April 1995, USAID developed four new climate change initiatives, totaling nearly \$80 million:

- Asia Sustainable Energy Initiative (\$13.5 million).
- Environmental Initiative for the Americas (\$9.7 million).
- Environmental Improvement Through Increased Energy Efficiency, Market Reform, and Improved Natural Resource Management (approximately \$50 million), active in Central and Eastern Europe and the New Independent States.

- Central African Regional Program for the Environment (\$7 million).

To support these regional initiatives and to advance the implementation of its Global Climate Change Strategy, USAID devoted an additional \$8.5 million in fiscal 1995 to a Global Climate Change Initiative. The initiative works with USAID missions to support (1) national climate change action planning efforts; (2) climate change technology needs assessments; (3) projects to help countries begin to mitigate greenhouse gas emissions through energy efficiency, renewable-energy, transport, and urban infrastructure activities; (4) activities to enhance existing and create new carbon sinks; and (5) outreach, education, and institutional capacity building. Following are descriptions of these four and additional projects related to the regional climate change activities of USAID and other agencies. The funding figures provided for each project represent only those expenditures that have been obligated by the date of this report's publication.

Asia Sustainable Energy Initiative

The ASEI is designed to foster the development and implementation of energy-production and -distribution strategies that reduce greenhouse gas emissions and support economic growth while minimizing economic and environmental costs. The initiative provides a sustainable approach to meeting the growing demand for energy services by supporting (1) increased institutional capacity for integrated resource planning, (2) pilot investment projects in energy-efficiency and renewable-energy technologies, (3) innovative financing mechanisms for energy-efficiency and renewable-energy activities, and (4) technology partnerships between U.S. and host country institutions.

The program focuses on three countries in Asia--India, Indonesia, and the Philippines--and has five primary components: (1) placement of resident Sustainable Energy Advisors in the USAID mission in each country, (2) implementation grants to identify and support pilot energy-efficiency and renewable-energy activities, (3) a training and technical assistance program with representatives from the three countries to build capacity to implement sustainable-energy programs, (4) utility partnerships to match senior technical staff from U.S. and in-country utilities for short-term technical assistance, and (5) environmental exchanges to bring senior policymakers and technical representatives to the United States for relevant training and course work.

In India, for example, the ASEI is assisting efforts toward reforming energy policy. It builds on earlier demonstrations of sugar-cane bagasse cogeneration. Using reform in one state, the program will demonstrate the impact of policy reform in encouraging expanded access to private-sector energy sources, opening markets, and creating opportunities for the use of new renewable-energy technologies. The program will also explore and demonstrate cogeneration options from biomass and other renewables, such as wind, hydro, and solar power.

- USAID, \$9 million, 1995-1997, India, Indonesia, and the Philippines

Environmental Initiative for the Americas

The EIA addresses global climate change in Mexico, Central America, and Brazil, as well as environmental pollution and related issues in the region. It helps disseminate and build markets for U.S. environmental technology in Latin America and the Caribbean (LAC) through partnerships in the energy-efficiency and renewable-energy fields among U.S. and regional governments, private-sector companies, and nongovernmental organizations.

EIA's four main components are: (1) to produce and use sustainable energy. (2) to integrate trade and environmental regulations, (3) to mitigate and prevent urban and industrial pollution, and (4) to conserve coastal and marine ecosystems. Primary activities include leveraging multilateral and private sources of capital to facilitate technology investment, establishing in-country advisors to support technical assistance efforts, supporting training and information dissemination to build implementation and enforcement capacity, and promoting institutional policy reform to standardize regulation and policy enforcement levels to encourage more sustainable development.

EIA's global climate change component highlights the links of sustainable energy production and use with the growth of LAC economies, the demand for energy services of rapidly growing urban populations, the need to reduce the poverty of marginalized rural and indigenous peoples, and the need to reduce greenhouse gas emissions from fossil fuel use and unsustainable wood burning.

- *USAID, \$9.5 million, 1995-1997, Brazil, Mexico, and Central America*

Environmental Improvement Through Increased Energy Efficiency, Market Reform, and Improved Natural Resource Management

USAID energy assistance programs in Central and Eastern Europe and the New Independent States help countries reduce greenhouse gas emissions by improving the efficiency of energy production and consumption and by supporting market reforms. Technical assistance and training support power sector restructuring, energy efficiency, and nuclear power plant safety. Highlights of the project's activities include:

- In the Russian Federation, the Energy and Environmental Commodity Import Program will import \$35 million of equipment to reduce greenhouse gas emissions from oil, coal, gas, and heavy industry in dozens of locations around the country. Partnerships between U.S. and local utilities will introduce demand-side management and energy-efficiency programs throughout the region.
- In Poland a new restructuring and regulatory reform project is supporting market reform of the power sector to promote competition, energy efficiency, and environmental retrofit of coal-fired power plants.
- In Ukraine, a three-pronged approach to energy efficiency includes: (1) energy audits and installation of energy-efficiency equipment in six combined power/heat plants that

are using coal and gas, (2) industry energy audits and management improvements in five major industrial facilities, and (3) demand-side management demonstrations at two distribution companies designed to lead to multilateral bank funding of expanded activities.

Also, a series of workshops is under way to improve the institutional capability of Kazakhstan and its four neighbors in the region (Kyrgyzstan, Turkmenistan, Tajikistan, and Uzbekistan) to trade electricity--and, ultimately, other energy commodities--on a more internationally accepted commercial basis. Such trading will allow cleaner and more cost-effective fuels to come to the market.

- *USAID, approximately \$50 million, 1995-1997, Central and Eastern Europe, Russia, and the New Independent States*

Central African Regional Program for the Environment

CARPE is aimed at reducing deforestation of tropical forests in the Congo Basin by establishing conditions and practices necessary for conservation and sustainable use. Through such activities as testing and demonstration of conservation approaches, capacity-building for key institutions in the region, training, technical support, and information dissemination, CARPE seeks to improve understanding of the overall ecology and biodiversity of the Congo Basin and to develop long-term strategies for addressing climate change and biodiversity problems. CARPE is also designed to create policy environments conducive to conservation and to develop a cadre of trained African specialists who can effectively impress on governments and the general public in the region the value and importance of conservation.

- *USAID, \$7 million, 1995-2000, Central African Republic, the Congo, Equatorial Guinea, Gabon, and Zaire*

Energy Efficiency and Market Reform Project

This project seeks to (1) improve efficiency and performance in the electricity, refining, industrial, and building sectors; (2) support energy-sector privatization and market reform; and (3) reduce safety risks at nuclear power plants. Energy-efficiency and demand-side management efforts are under way in Russia, Belarus, Ukraine, Armenia, Kazakhstan, and Kyrgyzstan in cooperation with the multilateral development banks and through U.S. private-sector contracts. These efficiency improvements, using state-of-the-art U.S. technologies, have resulted in annual energy savings of \$4.5 million when calculated at world energy prices. The Energy Efficiency and Market Reform Project is also engaged in cooperative efforts to reduce greenhouse gas emissions from natural gas flaring in Russia, rehabilitate gas distribution system designs in four major Russian cities, and develop a strategy for restructuring Russia's electric utility sector.

- *USAID, \$142 million, 1992-2001, New Independent States*

Regional Energy Efficiency

REE provides technical assistance, training, and equipment to accomplish three strategic objectives in Central and Eastern Europe: (1) improve energy efficiency and pricing; (2) support energy-sector restructuring, privatization, and modernization; and (3) improve nuclear safety. Through this project, U.S. government agencies and private organizations, in coordination with the World Bank and other donors, are working to improve the climate for private investment in the modernization and increased efficiency of energy systems, as well as to establish local private energy service and equipment supply companies.

Specific program components include: a grant to the International Energy Agency to carry out regional and country-by-country energy policy reviews in Poland, Hungary, the Czech Republic, Slovakia, Romania, and the Baltic countries to improve energy efficiency; regional technical assistance to promote policy and institutional reform within the energy industry, develop rational and environmentally sound energy investment programs, and enhance the business climate for energy industries and infrastructure in Central and Eastern Europe; an Electric Utility Partnership program that links U.S. electric utilities and industries with counterparts in Central and Eastern Europe to facilitate economic and technical reform of national utility systems, introduce modern management concepts, and expose Central and Eastern European industrial leaders to U.S. energy and environmental technologies and practices with a view to future technology transfer; and a Technology Cooperation program that takes advantage of specific DOE capabilities with respect to renewable-energy, energy-efficiency, and clean-coal technologies and to nuclear safety.

- *USAID and DOE, \$96 million, 1991-1996, Central and Eastern Europe*

Improved Public-Sector Environmental Services

This project provides technical assistance and training and technology transfer opportunities to improve environmental quality in Eastern Europe and to strengthen East European governments' capacity to provide public-sector environmental services. Although targeted primarily at industrial and municipal pollution reduction and regulation, and at environment risk assessment, the project has also reduced greenhouse gas emissions and encouraged energy efficiency improvements.

Through the application of "low-cost or no-cost" process changes, environmental audits, recycling, waste minimization, and efficient use of raw materials and natural resources, this project is promoting pollution prevention and is installing equipment at specific industrial facilities. It is also enhancing carbon sinks in the region through private-sector approaches to reforestation in Albania. Environmental Management Training Centers are being established in Bulgaria and Poland, and a "twinning" program is fostering long-term relationships between government ministries and EPA's regional offices in the United States for information exchange and technical assistance.

- *USAID and EPA, \$68.8 million, 1991-1996, Central and Eastern Europe*

Coalbed Methane Projects in Czech Republic, Poland, Russia, and Ukraine

Several ongoing projects reduce emissions of methane from coal mines by identifying and assessing profitable opportunities for coal mines to expand methane recovery in conjunction with coal mining. The efforts include assessments of coalbed methane resources, specific project opportunities, and the applicability of different U.S. technologies for methane recovery under local mining conditions, and establishment of Coalbed Methane Centers to disseminate information about investment opportunities to recover coalbed methane.

- *EPA and USAID, \$2 million, 1990-1996, Czech Republic, Poland, Russia, and Ukraine*

Environment/Global Climate Change

This project promotes policy reforms and encourages environmentally sound technologies and practices for the sustainable, efficient use of forest and energy resources, especially in Brazil and Mexico. Because the primary source of greenhouse gases in the region stems from the destruction of tropical forests, this project focuses heavily on the sustainable use of forest resources.

In Brazil, the project is providing training, management assistance, and basic infrastructure needs to local NGOs in the region. This assistance aims to increase NGO capacity to influence policy by working with government research agencies and carrying out demonstration field projects. To give added value to the existing forests, the project is supporting research and pilot demonstration activities for new nontimber forest products and for improving the cultivation of traditional products, such as Brazil nuts and rubber. The activities also include environmental education, environmental impact assessments, and components to improve timber management and management of protected areas.

Working with NGO partners, the Environment/Global Climate Change project has used \$2 million to purchase and conserve critical forested areas in Belize and Paraguay. In Mexico, it is helping the government analyze its policies and legal and institutional structures that encourage destruction of tropical and temperate forests. It is also working to consolidate and manage eight protected areas and their buffer zones, covering more than ten million acres in southern Mexico.

- *USAID, \$34.5 million, 1990-1996, Latin America (primarily Brazil and Mexico)*

Renewable Energy for Rural Chile and Argentina

This project aims to demonstrate renewable-energy technologies for delivery of clean power in remote areas. It will also create project models and explore financial tools that can facilitate widespread replication of similar projects.

- *EPA, \$900,000 in 1995, Chile and Argentina*

Americas' 21st Century Program

As the initial implementation of CORECT's regional strategy for the Western Hemisphere, "A21" was aimed at building a strong business and industrial capacity through renewable-energy products and services. It sought to identify and evaluate project opportunities and technical assistance needs to develop a framework to conduct sustainable-energy projects, to provide limited cost-sharing of project expenses, and to aggregate projects into portfolios for financing by multilateral development banks and commercial banks.

- *14 U.S. agencies, \$3.5 million in 1995, Western Hemisphere*

U.S.-Asia Environmental Partnership

This joint effort among eleven U.S. government agencies, trade associations, the Asia Foundation, and the Biodiversity Conservation Network seeks to establish energy-efficient and less polluting industrial regimes throughout Asia by mobilizing U.S. environmental experience, technology, and practice and linking them with the needs of private industry and governments in Asia and the Pacific. US-AEP develops these links in a variety of ways, including helping U.S. firms introduce their products, technology, and services to the rapidly growing Asian market; providing assistance in waste reduction to industries in six ASEAN countries; and sponsoring conferences and training workshops on environmental management and pollution-prevention technologies.

Another creation of US-AEP--the Environmental Technology Fund--awards grants to small- and medium-sized U.S. firms to stimulate demand for and facilitate the transfer of energy-efficiency and other environmental technologies to Asia and the Pacific. The Partnership's NGO-Business Environmental Partnership awards grants to Asian NGOs working collaboratively with business, public utilities, or local government in addressing environmental problems.

- *USAID-led, \$85 million, 1992-2002, 35 Asian and Pacific Basin countries*

Asia-Pacific Initiative for Renewable Energy and Energy Efficiency

This partnership among EPA, DOE, the Export Council for Renewable Energy, the Export Council for Energy Efficiency, and the International Institute for Energy Conservation will do market assessments, including such activities as matching buyers and suppliers of renewable-energy and energy-efficiency technologies. It will be capped by a major international conference in 1997 in Indonesia.

- *EPA, DOE, and USAID, \$625,000 in 1995, Asian and Pacific Basin countries*

Energy Efficiency and Sustainable Development Centers

This project has established centers in Bulgaria, the Czech Republic, Poland, Russia, China, and Ukraine to facilitate the transfer of U.S. renewable-energy and energy-efficiency technologies. The centers arrange contacts with regional energy decision makers and provide marketing assistance for U.S. business representatives, while serving as local centers of expertise and information. These nonprofit, independent local organizations

promote economic policy reform and transfer of technologies through their advocacy work, demonstration projects, sectoral studies, seminars, business partnership events, and other activities.

- *DOE and USAID, \$600,000, 1995-1996, Eastern Europe and the New Independent States*

Coal and Technology Export Program

This program helps coal-dependent countries reduce their greenhouse gas emissions, while continuing to meet their energy needs, by developing efficient, economic, and environmentally acceptable projects using U.S. clean-coal technologies. By producing comparable amounts of power using less fuel, these technologies can reduce CO₂ emissions by 20-25 percent, while cutting acid-rain emissions that can degrade forest carbon sinks.

- *DOE, TDA, and SBA, \$1.9 million, 1995-1996, Asia, Eastern Europe, and the New Independent States*

Famine Early-Warning Systems

These systems aim to ensure food security in famine-prone African countries by developing famine early-warning systems within USAID, improving early-warning capacity in host countries, and increasing cooperation among international donors. Institutional capacities being developed, including surveillance and reporting methods, would be important adaptive mechanisms under a changed climate, especially one with lower and less reliable rainfall.

The current project will reinforce existing African early-warning programs for food and nutrition problems and famine and will develop or expand warning systems in semi-arid and drought-prone countries outside the Sahel. It will also explore ways to link and apply early-warning technology and experience to food security and other agricultural development issues.

- *USAID, \$17 million, 1990-99, Africa*

Southern African Regional Power Pooling Project

This project supports the Southern African Development Community's (SADC's) efforts to provide electric power through an efficient regional power pool. Improving regional access to electric power will yield significant reductions in carbon dioxide emissions and will improve the viability of existing sinks by decreasing the rate of uncontrolled burning of fossil fuels, wood, and biomass. The results will be decreased deforestation and improved conditions for afforestation.

There is a considerable body of U.S. expertise and "lessons learned" that can be capitalized upon by the twelve nations of the SADC. Initially, the project will be embodied

in a regional power-pooling workshop, to be convened in southern Africa, to address the governance, institutional, technical, and financial issues that must be resolved.

- *DOE, funding to be determined, SADC member states*

Renewable Energy for Africa Development Training

In the summer of 1994, DOE and Texas Southern University sponsored training sessions of approximately twenty-five faculty members from several southern African nations on applied renewable-energy technologies. The training was facilitated through the efforts of Renewable Energy for African Development, or REFAD, an NGO dedicated to the sustainable development of renewable-energy technologies in Africa.

A second session was held in the summer of 1996. The program will continue to train cadres of renewable-energy trainers to serve as cores of programs in secondary and post-secondary educational institutions in Africa.

- *DOE, 1994-1996, Southern Africa*

Sahel Water Data and Management III and IV

This project aims to improve the management of water resources in the Sahel, which had below-normal rainfall in the 1980s and early 1990s. It provides computer hardware and software, technical assistance, and training to enable the regional Agrometeorological/Hydrological program to collect, analyze, and disseminate climatic, hydrologic, and meteorologic information to forecast crop production.

Current areas of concentration are: (1) institutional capacity leading to Sahelianization; (2) new products and applications in famine early warning, agricultural production, and natural resource management; and (3) pilot activities, especially using geographic information system (GIS) applications. The region-wide water resource monitoring, data gathering, and dissemination capabilities built up by this long-term project constitute an important underpinning for observing and coping with future climate change and attendant weather variability.

- *USAID, \$21.23 million, 1987 to 1994 and \$12.82 million, 1994-1997, Sahel region*

Individual Country Projects

The following projects were designed to respond to the individual socioeconomic, environmental and other related needs of developing countries and countries with economies in transition. The funding figures provided for each project represent only those expenditures that have been obligated by the date of this report's publication.

Electrification for Sustainable Development, USAID/GEF Renewable Energy Component

This project is designed to improve rural electrification systems by promoting productive electricity uses and new system construction, providing technical assistance in

system operation and maintenance, and supporting the creation of a rural electric cooperative finance company. The USAID/GEF component promotes the reduction of greenhouse gas emissions through the use of renewable-energy systems in rural areas. The project demonstrates innovative mechanisms for sustainable financing and integration of renewable-energy systems in the electrification of Bolivia, including solar, wind, small hydro, and biomass energy projects.

- *USAID, \$9 million, 1991-1996, Bolivia*

Brazil Integrated Environmental Management Project

Building upon Brazil's Environment/ Global Climate Change project, this project aims to increase the protection and sustainable use of natural resources in Brazil's critical regions for carbon sequestration and biodiversity, especially the Amazon and the Atlantic Coastal Rain Forest, and to reduce greenhouse gas emissions from deforestation and wasteful energy use.

The project's major components include: (1) policy analysis resulting in policy reform to reduce economic incentives to deforestation; (2) introduction of practices to increase the long-term economic benefits that local people receive from forests; (3) improved conservation in protected areas; (4) demonstration of techniques (e.g., agroforestry) and technologies (e.g., solar power, efficient light bulbs) that provide economic alternatives to deforestation or wasteful energy use; (5) training and research in improved forest management, park protection, environmental law, and modern energy technologies; (6) leveraging multilateral funding for forest protection and clean energy use; and (7) institutional strengthening of NGOs.

- *USAID, \$3.7 million, 1996-99, Brazil*

Santiago Clean Cities Project

Issued from the Hemispheric Energy Symposium, this project involves collaboration between DOE and the Chilean National Energy Commission to explore the possibility of introducing natural gas buses into the transportation mix for the city of Santiago. The city and its stakeholders will form a task force that will develop a strategy for improving Santiago's air quality.

- *DOE, \$40,000, 1996-1997, Chile*

Beijing Energy Efficiency Center

EPA and DOE cooperated with the World Wildlife Fund (WWF) to establish this quasi-nongovernmental policy and technology research institute affiliated with the Energy Research Institute of the State Planning Commission. The Center is implementing a number of high-profile initiatives, including integrated resource planning and demand-side management training and pilot projects, China's Green Lighting program, and a Global Environment Facility (GEF) project to develop energy service companies.

- *EPA and DOE, \$110,000, 1994-1995, People's Republic of China*

Industrial End-Use Energy Efficiency Studies

EPA will provide funding to the Lawrence Berkeley National Laboratory to conduct detailed studies of industrial end-use energy-efficiency paths for certain industrial sectors in China, beginning with building materials (due to the high carbon dioxide emissions of cement production) and buildings. Studies will include costs, energy conservation benefits, local environmental benefits, and greenhouse gas impacts.

- *EPA, \$60,000 in 1996, People's Republic of China*

Integrated Gasification Combined Cycle Power Generation Deployment to China

This project will conduct environmental benefits and feasibility studies to support a demonstration of Integrated Gasification Combined Cycle (clean coal) technology. This technology provides up to 23 percent reductions of carbon dioxide emissions through efficiency gains.

- *EPA and DOE, \$500,000 in 1995, People's Republic of China*

U.S.-China Center for Energy and Environment Technology

Located at Tsinghua University in Beijing, the Center is a focal point for cooperative projects. Working in partnership with Tulane University in New Orleans, Louisiana, the project is initially focusing on energy-related environmental technology.

- *EPA, DOE, \$400,000 in 1995, People's Republic of China*

China Energy-Efficient, CFC-Free Refrigerator Project

This project aims to transform the Chinese refrigerator industry to effectively produce and market CFC-free, energy-efficient refrigerators. As a first step in this process, EPA, the China National Environmental Protection Agency, and the China National Council for Light Industry have worked together to develop a prototype CFC-free refrigerator that uses substantially less electricity than comparable baseline models. Funded by the Montreal Protocol Multilateral Fund, this work was undertaken in the context of CFC phaseout at a Chinese factory.

Further activities include energy-efficiency labeling, manufacturers' incentive programs, consumer education, training for refrigerator producers, technical assistance for increasing compressor efficiency, and technical support to factories for conversion to energy-efficient refrigerator production.

- *EPA, 1993-97, People's Republic of China*

Coalbed Methane Project in China

In cooperation with the GEF and the Chinese Ministry of Coal, EPA conducted assessments and pilot projects for capturing abundant gas resources at Chinese mines, with

concurrent mine safety, power production, and climate benefits. A Coalbed Methane Information Clearinghouse is housed at the Ministry of Coal and has conducted considerable outreach to U.S. and other companies interested in this market. The Clearinghouse publishes a journal in Chinese and English, has hosted several domestic and international seminars, and has developed with EPA an economic analysis model to identify profitable projects to reduce methane emissions.

- *EPA, \$630,000, 1994-1996, People's Republic of China*

Mobile Sources

EPA is actively engaged with the Chinese government at several levels to pursue vehicle emission controls, environmentally sound vehicle production, and the elimination of lead in gasoline. In cooperation with the Chinese government and the International Institute of Energy Conservation, EPA delivered workshops in Shanghai and Xiamen on controlling air pollution from mobile sources and phasing out lead in gasoline. Future activities are now under discussion with the Chinese government.

- *EPA, \$35,000 in 1996, People's Republic of China*

Wind Energy Assessment

This project seeks to accelerate the large-scale use of wind-energy technology in China by conducting wind mapping and site-specific monitoring. It will demonstrate at the national and provincial levels that wind energy can provide clean, cost-effective, electric-generating capacity.

- *EPA, \$160,000 in 1995, People's Republic of China*

Forest Conservation and Management

Known as BOSCOA, this project promoted the sustainable development of forest and agricultural resources in the buffer zone surrounding Costa Rica's Corcovado National Park. Activities included the establishment of a research, training, and extension center; regional conservation planning and management; and various subprojects involving local groups. In this way, BOSCOA helped to develop and demonstrate alternatives to deforestation to a local economy long based on resource extraction.

- *USAID, \$1.9 million, 1990-1995, Costa Rica*

Forest Resources for a Sustainable Environment

FORESTA sought to improve forest resource management in Costa Rica's Central Cordillera through conservation, sustainable forestry, and reforestation activities. This project provided support for the development of guidelines and regulations for logging controls, tree harvesting, logging roads, and silviculture practices; encouraged the reforestation of cleared land under a forest management plan; and conducted a feasibility study for a regional timber marketing center to help develop an integrated, sustainable forest industry.

- *USAID, \$7.5 million, 1989-1996, Costa Rica*

Power Sector Support Program

This program aims to rehabilitate electricity-generating capacity, increase efficiency, and stimulate investments in energy efficiency. It is reducing greenhouse gas emissions through infrastructure investments and technical and policy assistance. The modernization of the Cairo West thermal power station's boilers and turbine generators, as well as the modification of the boilers to burn both natural gas and mazout oil, are expected to increase the plant's capacity from 300 to 350 megawatts, while decreasing its fuel consumption rate from 275 grams to 260 grams per kilowatt hour, thereby greatly reducing its greenhouse gas emissions.

The program is also assisting the Egyptian government in its efforts to adopt environmentally sound practices and reduce electricity subsidies that discourage conservation. In partnership with the World Bank, the government developed a national Environmental Master Plan identifying Egypt's environmental problems and outlining an action plan to address them. The New and Renewable Energy Authority, recently established under the Power Sector Support program, will help carry out the government's action plan and meet future demands for environmentally sound energy by promoting new and renewable sources. The program is also helping to expand the operating data collection capability of the National Energy Control Center, which will enhance the reliability and efficiency of the overall national power system.

- *USAID, \$661 million, 1989-1996, Egypt*

Energy Conservation and Environment Project

ECEP is designed to (1) promote and accelerate the adoption of improved commercial technologies, processes, and practices to increase energy efficiency and (2) enhance Egyptian institutional capability to implement energy-efficiency measures. The project is thus demonstrating proven energy-efficient technologies that can help private- and public-sector enterprises adjust to the higher energy costs that will emerge as the Egyptian government deregulates prices.

ECEP focuses on ten different technology applications: cogeneration, waste heat recovery, combustion control, power factor correction, high-efficiency lighting, high-efficiency motors, energy management systems, process controls, solid fuel boilers, and insulation and refractors. Forty demonstrations of these technologies are planned during the life of the project, at an equipment cost of roughly \$23 million. The remaining funds cover technical assistance, training, and promotion.

- *USAID, \$51.6 million, 1989-98, Egypt*

Program for the Acceleration of Commercial Energy Research

This USAID/India program is helping to overcome the energy constraints in India's economic development by promoting the development of new or innovative products or processes relevant to the Indian power sector. PACER promotes commercialization of emerging energy technologies, administers a revolving fund for research awards and grants, and encourages Indo-U.S. joint ventures. PACER also provides grant assistance for policy analyses and studies related to energy use in India.

Since its inception in 1987, PACER has assisted more than twenty-five projects in developing and validating energy technologies, including technologies for renewables and energy efficiency. For example, PACER is providing matching funds totaling \$2 million for an Indo-U.S. joint venture in energy-efficiency technology with industrial applications. PACER also has ongoing projects in energy-efficient regenerative burner development, a 500-kilowatt biomass gasifier-based power-generation system, and continuous fluidized-bed furnaces for heat treatment.

- *USAID, \$17.5 million, 1987-1995, India*

India Private Power Initiative

Through close cooperation with the Indian government, the World Bank, the Asian Development Bank, and other lending institutions, IPPI is working to achieve its goal to establish a sustainable, environmentally conscious private power industry in India. Over \$5.5 billion in potential U.S. investments in India's power sector have been facilitated through IPPI's successful leveraging of technical assistance and training to the State Electricity Boards.

IPPI provides hands-on technical assistance to State Electricity Boards and the Indian government to build in-country capabilities to evaluate and process the numerous project proposals now pending before the government, as well as to help with the formulation of the project contract documentation necessary to attract international financing. It also provides countrywide training on the fundamental aspects of private participation in the power sector.

- *USAID, \$3 million, 1993-1996, India*

Renewable Energy Commercialization Project

The RECOMM project is designed to commercialize renewable-energy systems across a wide range of technologies, applications, and services. This activity is specifically intended to: (1) catalyze the commercialization for high-potential renewable-energy technologies; (2) help develop commercially successful, replicable models of renewable-energy products and services; (3) improve access to financing and capital for renewable-energy development; (4) facilitate renewable-energy partnerships between U.S. and Indian companies; and (5) strengthen the overall environment in India for renewable energy. The project also includes funds for commercializing rural photovoltaic energy, for developing a bagasse cogeneration program, and for supporting a wind energy mapping activity.

- *USAID, \$639,000, 1995-98, India*

Energy Management Consultation and Training

Through four major components, EMCAT promotes a systems approach to improving energy efficiency in the Indian electric power sector. Two energy supply components provide technical assistance and training to enable the Power Finance Corporation to effectively use funds from multilateral development banks to modernize, rehabilitate, and improve management for existing energy systems and enhance the environment for private power development. And two end-use components have provided funds to the Industrial Development Bank of India to study the feasibility of investments to enhance energy-efficiency and private power-generation projects.

- *USAID, \$27 million, 1991-1996, India*

Greenhouse Gas Pollution Prevention Project

This collaborative project between USAID/India and the GEF represents a two-part strategy to reduce greenhouse gas emissions from energy generation. Both components are designed to address the major market, financial, and institutional obstacles to introducing these technologies and, thereby, to demonstrate their competitiveness with other sources.

The first component is a near-term strategy to increase the efficiency of coal use by introducing coal-conversion efficiency measures and state-of-the-art coal-conversion technologies at existing power plants. U.S. technical advisors are assisting the National Thermal Power Corporation and other state utilities in promoting efficiency in thermal power generation and installing advanced environmental monitoring and control techniques to reduce pollution.

The second component is part of a longer-term strategy to reduce dependence on greenhouse gas-emitting fossil fuels by promoting more efficient bagasse (sugar cane waste) cogeneration technologies, which produce no net greenhouse gas emissions, to exploit currently unused biomass resources. The plants use efficient, high-pressure multi-fuel boilers and high-efficiency turbines and rely on supplemental biomass fuel, rather than fossil fuels during the off season when sugar cane is not available. This component will provide incremental cost support for six demonstration projects in addition to technical assistance, training, and cost-shared research grants for developing cane trash and other viable biomass fuels.

- *USAID, \$6 million, 1995-2001, India*

Natural Resources Management Project

The NRMP provides support for managing Indonesia's protected areas and forests through technical assistance, training of field staff, and policy analysis. The project is studying major policy and market failures that result in resource depletion, and national accounting methods for natural resources. It also supports a pilot effort to develop viable,

multi-purpose management approaches for selected protected areas, as well as applied research on priority management needs for natural production forests and protected areas.

- *USAID, \$30 million, 1990-1997, Indonesia*

CLEAN/Energy Project

USAID/Jakarta has developed the Coordinated Local Environmental Action Networks Project (CLEAN/Energy) to promote renewable energy and energy efficiency. Currently in the initial stage of its implementation, CLEAN/Energy will achieve its goals through four primary areas of activity: (1) creation of an enabling regulatory environment for energy efficiency and renewable energy, (2) development of cleaner energy supplies through the promotion of renewable-energy technologies, (3) improvement in the efficiency of conventional energy generation and transmission, and (4) improvement in end-use efficiency. Assuming that coal is the marginal supply source, the project estimates that potential carbon dioxide emissions could be reduced by as much as 1.2 million tons in the first year.

- *USAID, \$800,000, 1997-2002, Indonesia*

Windpower for Islands and Nongovernment Development

This project identifies favorable wind areas in Indonesia's eastern islands and demonstrates the commercial feasibility of wind systems in at least ten locations for water pumping, battery charging, electrification, and communication. By working with nongovernment organizations and community representatives, the project is teaching local people how to set up and manage small-scale, nonfossil-fuel energy activities; operate and maintain wind-powered generating systems; and build self-sustaining local enterprises.

- *USAID, \$2.8 million, 1994-98, Indonesia*

Environment/Global Climate Change, Mexico Renewable Energy Component

This USAID project, in collaboration with DOE, is supporting the expansion of the government of Mexico's nonconventional rural electrification program and other renewable-energy activities. It focuses on socially productive uses of renewable energy, including water pumping for potable water supply, livestock watering, and small-scale irrigation. The principal renewable-energy technologies will be photovoltaics, wind-power-driven electric turbines, and hybrid systems combining these two technologies. Installation of off-grid renewable-energy systems will avoid the greenhouse gas emissions of the equivalent fossil fuel-generated electricity, while providing for sustainable development in Mexico.

- *USAID and DOE, \$4 million, 1990-1996, Mexico*

Energy Demand Management Project

This project focused on reducing energy waste and improving the efficiency of energy use in Morocco by introducing energy-demand management techniques into

important sectors of the Moroccan economy, including agro-industry, construction materials, and hotels. It combined hands-on energy and environmental audits of forty-six large and medium-sized firms in four key industrial sectors, links with Moroccan engineering training institutions, and information dissemination on the benefits and techniques of energy conservation targeted to technical professionals and company and plant managers.

The energy and other plant audits recommended measures that led to more than \$4 million in annual savings. In terms of greenhouse gas reductions, these audits are estimated to have prevented annual emissions of approximately 140,000 tons of carbon dioxide. Overall, the EDM project succeeded in developing a demand for sophisticated energy and environmental audits and associated energy-efficiency services in Morocco's rapidly growing private sector.

- *USAID, \$8.6 million, 1988-1996, Morocco*

Philippines Demand-Side Management Project

The overall goal of the Philippines DSM project is to eliminate or defer the need for new fossil fuel-based power-generation facilities, and to eliminate the need for inefficient back-up systems, thus reducing the corresponding greenhouse gas emissions. The project comprises a three-pronged strategy of (1) assessing the potential for utility demand-side resources; (2) providing technical assistance to help establish legislation, policies, and regulations in support of DSM and integrated resource planning; and (3) demonstrating the technical, economic, and market viability of DSM through the design and implementation of an industrial-sector DSM pilot program. The Philippine Department of Energy estimates that through the project's reduction in marginal generation capacity, 1.5-5 million tons of carbon dioxide emissions will be avoided annually by 2010.

To maximize the program's impact, USAID and the Asian Development Bank (ADB) are conducting a coordinated effort whereby USAID provides grant-funded technical assistance and technical services, and the ADB provides specialized project finance for Philippine DSM investments. The project was partly supported by a portion of the U.S. funding commitment to support the Global Environment Facility.

- *USAID, \$2 million, 1995-1998, Philippines*

Philippines Assistance Support Project, USAID/GEF Renewable Energy Component

This project is a multi-donor effort to help the Philippine government develop economic infrastructure and stimulate investment. Project activities include studies, operational support to the Committee on Official Development, and funding of a private-sector pre-investment facility. The USAID/GEF renewable-energy component will help the Philippines demonstrate and test innovative financing approaches for renewable energy in economic development. This program helped to finance projects to supplant some 15-18 megawatts of fossil energy systems directly and will help with indirect assistance for

another estimated 20-25 megawatts, with corresponding reductions in greenhouse gas emissions.

- *USAID, \$3.75 million, 1990-1995, Philippines*

Renewable Energy Financing and Technical Assistance

REFTA seeks (1) to reduce the technical, financial, economic, and institutional risks associated with the developing renewable-energy technologies in the Philippines and (2) to use proven mechanisms to encourage public- and private-sector investment in this field. USAID is conducting this project with funding from the U.S. commitment to the Global Environment Facility and from Winrock International.

- *USAID, \$3.75 million, 1994-1996, Philippines.*

Environment and Natural Resources Management

This USAID/Philippines project promoted the sustainable management of the Philippines' tropical forests by focusing on policy reforms, natural resource protection, and incentives for long-term stewardship of public lands. Project members worked with the Philippine government to empower local communities to protect and manage many of the country's forest estates, ban logging of primary forests, and develop and implement site-specific plans to conserve and develop natural forests. The project also promoted economic efficiency in the forest products industry, which is managing existing natural forests more productively and sustainably, ensuring their continued survival as carbon sinks.

- *USAID, \$125 million, 1990-1994, Philippines*

Polish Coalbed Methane Project

Two U.S. agencies, in cooperation with the Polish Ministry of Environmental Protection, are jointly funding a \$1.1 million project to demonstrate a new technology to use methane from coal mines as fuel for a brine-water treatment facility. The submerged evaporation technology began as a DOE/SBIR effort in the early 1990s and has since led to multiple applications.

Phase I field testing was conducted at a southern Poland mine site. The Phase II field demonstration successfully demonstrated the system's technical feasibility. Upon its completion, this project is expected to significantly reduce coal mine methane emissions as well as provide a source of clean water for the region.

- *DOE and EPA, \$600,000, 1993-1996, Poland*

Environmental Policy and Technology, Russian Air Management Program

Part of an overall environmental policy project, RAMP is designed to demonstrate how improved institutions, policies, and practices in air-quality management can help solve

air pollution problems in Russian cities. RAMP also aims to identify activities that will reduce greenhouse gas emissions.

The program has begun by assisting Russian officials in a short-term study of Volgograd's air-quality problems and in identifying low- and no-cost emission-reduction measures. Using experience gained in Volgograd, RAMP will then help Russia define and implement appropriate changes to national, regional, and local approaches to air-quality management. Through training, technology transfer, and policy development, RAMP will assist Russia in drafting air-quality legislation and regulations, establishing standards, and setting emission limits and permit requirements.

- *USAID and EPA, \$35 million, 1992-1996, Russia*

GAZPROM Working Group

This working group aims to identify and assess project opportunities to reduce methane emissions from Russia's natural gas system through the application of U.S. technologies. Approximately seventy U.S. companies are participating in this effort, together with DOE, EPA, and GAZPROM, the Russian natural gas company. Working group members have identified a number of potentially profitable projects that could improve the efficiency of Russia's natural gas system and reduce methane emissions, and several demonstration projects have been successfully completed. A recent achievement was the first actual measurement of leaks in the GAZPROM pipeline system.

- *EPA and DOE, \$500,000, 1993-1996, Russia*

Russian-American Fuel Cell Consortium

This joint U.S.-Russian consortium will draw on the scientific and engineering expertise of the United States and in Russia to advance the development of commercially viable fuel cell technologies and promote defense conversion goals. American industry is expected to play a pivotal role in the consortium's projects and has committed to cost-sharing projects. Seven initial projects dealing with key technological impediments to speedy commercialization have already been identified.

- *DOE, \$5-10 million, 1997-2001, Russia*

Promoting Energy Efficiency in Russian Buildings

EPA is helping Russia develop new building codes to improve the energy efficiency of its buildings. Annual energy consumption in Russian buildings amounts to the equivalent of over 370 million tons of coal. These buildings are also much less efficient than buildings found in western Europe or North America, so there is a large potential for emission reductions through energy efficiency.

- *EPA, \$390,000, 1994-1997, Russia*

Integrated Resource Planning

EPA has worked with an NGO and private-sector consultants to introduce integrated resource planning tools in the Moscow and North Caucasus regions of Russia. Project achievements include the preparation of an investment package that raised up to \$24 million for the Mosenergo electric utility company, and the development of energy regulatory bodies in the North Caucasus. The project is also engaged in consumer education about energy efficiency.

- *EPA, \$430,000, 1993-1994, Russia*

Senegalese Southern Zone Water Management

Below-average rainfall in the 1980s in Senegal resulted in extended tidal flooding of low-lying deltaic rice farms. The coastal wetlands, which normally were saturated with rainwater and thus kept the sea at bay, absorbed the sea water. This scenario could become widespread in West Africa with sea level rise and, in semi-arid areas, less rainfall.

This project aims to increase cereal production in southern Senegal by improving farmer recovery of land and use of water for agricultural production. It includes environmental monitoring and construction of water-retention structures and tidal barrages in cooperation with village water-management committees. Activities such as these may be required on a more general basis to protect coastal deltas in the face of drier climates and sea level rise.

- *USAID, \$18 million, 1988-1996, Senegal*

Community-Based Natural Resources Management

This project aims to improve forest resource management in Senegal through direct participation by rural communities and the private sector in land-use planning and conservation. Building on a 1991 reforestation project in which 43,000 participants planted trees on 1,300 hectares (3,200 acres) of land, the follow-on project includes continued tree-planting and forest-regeneration activities to instill in the population a sense of stewardship for natural resources. The project aims to work with community groups and farmers to plant three million trees, and to protect and manage natural forest regeneration on 200,000 hectares (494,000 acres) of land. A related policy and institution-strengthening component will work through Senegal's national environmental plan process to ensure that these gains are sustained.

- *USAID, \$12 million, 1993-1999, Senegal*

Bilateral Agreements for Cooperation on Energy Efficiency

China

In February 1995, DOE and the China State Science and Technology Commission signed a Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization. In October 1996, they signed the

Energy Efficiency Annex to this Protocol. Activities under the Annex encompass energy-efficiency policy, information exchange and business outreach, district heating, cogeneration, energy-efficient building demonstration, energy-efficient motor systems, industrial process control, lighting, energy-efficient electrical transformers, and finance.

Ghana

In the spring of 1995, DOE and the Ghanaian Ministry of Mines and Energy signed an agreement on Cooperation in Energy Policy, Science and Technology, and Development. The areas of cooperation under this agreement include energy efficiency and renewable energy; fossil energy, including clean coal technology; environmental management; and independent power project development. During a 1996 U.S. visit, a Ghanaian delegation learned about the operation and management of DOE's Industrial Assessment Center program. In this program, university centers conduct energy and waste assessments in small and medium-size companies to reveal opportunities to improve energy efficiency and reduce waste. Ghana is establishing a similar center at the University of Science and Technology in Kumasi.

India

Upon signing a Memorandum of Understanding in July 1994, DOE and the government of India agreed to cooperate in the following areas: industrial process efficiency of the pulp and paper, mini-steel, and chlor-alkali industries; utility programs; electric motors and motor systems; cogeneration; transmission and distribution of electricity; energy-efficiency labeling, standards, and testing; education and training; finance; and sustainable cities. To execute this cooperation, the United States and India agreed to form teams in each of these areas and to draft action plans. Some team activities are under way. For example, the Electric Motors team is cooperating with the Indian team in implementing showcase demonstration projects in India. Successful replication of these demonstration projects will reduce energy consumption and emissions of greenhouse gases.

Mexico

On May 7, 1996, representatives from DOE and the Mexican Secretariat of Energy signed an Agreement for Energy Cooperation. Among the agreement's objectives are to develop a framework for cooperation between the two parties to facilitate the establishment of collaborative activities in the fields of research, development, and commercialization to promote improved use of renewable-energy, energy-efficiency, and fossil-energy technologies.

Renewable Energy for South Africa

DOE and USAID have been instrumental in developing business plans for the solar home system market in South Africa, with the initial pilot of 2,500 solar systems being installed in late 1996 or early 1997. Approximately 20 percent of South Africa's rural population is expected to remain unconnected to the electricity grid for at least twenty years. The South African government has elected to shoulder the costs to electrify 2,000 clinics and 16,800 schools through photovoltaics, but is seeking long-term sustainable solutions for electrifying an estimated 2.5 million homes and 100,000 small businesses.

- *DOE and USAID, \$1.75 million, 1996-1997, South Africa*

PV Manufacturing Facility

Through DOE's National Renewable Energy Laboratory, the United States helped facilitate the first investment in Suncorp Systems. This sister company of U.S. Suncorp Manufacturing intends to sell solar home systems throughout South Africa and possibly Southern Africa via a network of franchises. The photovoltaic manufacturing facility Suncorp Systems opened in August 1995 in South Africa and has maintained a positive cash flow since November 1995. When the plant reaches full capacity, it will produce 1.4 megawatts annually.

- *USAID and DOE, \$2 million in 1995, South Africa*

Multilateral Organizations

Along with its bilateral activities, the United States works within various multilateral fora to address the problem of global climate change. Numerous organizations have integrated climate-related activities into their operations since the Framework Convention on Climate Change (FCCC) entered into force. The United States actively supports this development, recognizing that multilateral efforts are essential to achieve progress on climate change issues.

Owing to its heavy technical and financial responsibilities in many multilateral fora, the U.S. plays a leadership role in advancing climate-related objectives in appropriate organizations. This section describes the U.S. role in, and contributions to, some of the chief financial and policymaking bodies relevant to climate change.

Framework Convention on Climate Change

In the existing Convention framework, the United States has seconded technical experts to the FCCC secretariat to help implement methodological, technical, and technological activities. For example, the United States has:

- Reviewed the national communications of other Parties and assisted with work on the methodologies for inventorying national emissions.
- Sought to ensure that all countries undertake appropriate analyses of their own circumstances prior to action--and then act on these analyses.
- Suggested and, where possible, 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).
- Used its best diplomatic efforts to prod those in the international community reluctant to act, seeking to convince them that the issue is critical and warrants global attention.

As a result of these efforts, the United States expects the ongoing negotiations will successfully conclude in late 1997, and the successful implementation of both the Convention and the new legal instrument will protect the Earth against the potential hazards of global warming.

Other Relevant Conventions and Agreements

The United States is a party to several international agreements that are also relevant to the control of greenhouse gases or otherwise work to mitigate climate change:

- The 1985 Vienna Convention for the Protection of the Ozone Layer and its 1987 Montreal Protocol on Substances That Deplete the Ozone Layer
- The Intergovernmental Panel on Climate Change
- The Geneva Convention on Long-Range Transboundary Air Pollution and its NO_x Protocol
- The U.S.-Canada Air Quality Agreement
- The Commission on Sustainable Development
- The Commission on Environmental Cooperation

Global Environment Facility

The GEF was created on a pilot basis in 1991 as a collaborative effort between the World Bank, the United Nations Development Program, and the United Nations Environment Program to finance efforts in developing countries and countries with economies in transition to protect the global environment. Specifically, the GEF helps reduce the threat of climate change, reverse the depletion of the ozone layer, arrest the loss of biodiversity, and protect international waters.

The GEF provides the multilateral framework necessary for managing the global environmental commons. Since no country's actions alone can protect the global environment, countries only have an incentive to act if all other major countries cooperate. Instead of focusing solely on conservation, the GEF has a unique mission--to support efforts by developing countries to redirect their development paths toward pro-environment, pro-growth alternatives.

The GEF underwent an independent evaluation and a fundamental restructuring in 1993, and began full-scale operations in July 1994. The United States has played a leadership role in the restructuring process and subsequent reforms. Achievements include: establishment of a governing body representing all participating countries; development of

a clear operational strategy; expedited procedures for national communications support and related enabling activities and for medium-sized projects; observer status for NGOs at GEF meetings, along with public availability of much documentation; strong guidelines for public participation in GEF project preparation and implementation; and a strong monitoring and evaluation framework.

Project Portfolio

To date, the GEF has committed about \$1.58 billion for well over two hundred full enabling activities, research, and investment projects. In addition, the GEF has supported over three hundred local projects in over thirty countries through its Small Grants Program. U.S. government agencies, foundations, NGOs, and private firms have been crucial in the development and implementation of numerous climate focal area projects in the portfolio, as well as several currently in the project development pipeline.

Leveraging New Resources

Especially in its climate focal area, the GEF is increasingly successful in leveraging additional financing for sustainable development projects. For example, GEF projects implemented by the World Bank are leveraging \$2.7 billion in additional co-financing. Public funds can never be sufficient and, in some cases, can threaten distortions in economic development.

The United States has led the GEF's efforts to engage the private sector in climate change, such as by reducing barriers to the commercial viability of low- or no-greenhouse gas technologies. This may be the GEF's most important function. Success in addressing climate change clearly depends on mobilizing private-sector investment, which is fundamental for the development and proliferation of new technologies. The private sector is far more successful than the government in transferring technologies in an economically sustainable manner.

U.S. Financial Contributions

Aside from project development investments and co-financing by agencies and nongovernmental sources, the United States is the second largest contributor to the Operation Phase to date, with \$190 million. The Administration has requested the full U.S. pledge, although Congress has appropriated less than that amount due in part to governmentwide budget deficit-reduction measures that are important to not only the United States but the world economy. Nonetheless, the Administration continues to consider the GEF a high priority and is working with Congress to fulfill its current pledge of \$430 million.

Multilateral Development Banks

The multilateral development banks (MDBs) represent a powerful tool for implementing environmental policy goals. The United States has urged the MDBs to reassess the use of their resources with a view toward encouraging sustainable development. Much progress has been made in this area in recent years, as awareness of

the interdependency between economic growth and sustainable resources has become widespread.

- The *African Development Bank* focuses on capacity development in borrowing countries to build up the institutional, statutory, and regulatory frameworks necessary for implementing an integrated least-cost planning approach that encompasses energy supply and efficiency, and the environment. The ADB is also working on developing renewable and alternative energy sources.
- The *Asian Development Bank* is allocating more resources to focus on energy efficiency and conservation, unconventional energy resource development, and intensified environmental initiatives. Its policies concentrate on moderating energy demand, improving efficiency in resource allocation, and strengthening institutions for national energy-conservation activities, with greater focus on policy analysis.
- The *European Bank for Reconstruction and Development's* energy operations aim primarily at improving energy efficiency in both supply and demand. To address these aims, the EBRD promotes pricing reform, improved standards for insulation, and the introduction of more energy-efficient technology. Bank assistance will be based on least-cost energy plans or, preferably, an integrated resource planning strategy.
- The *Inter-American Development Bank* will continue to assist borrowing countries in adopting energy-development strategies that are environmentally sustainable by: (1) elaborating on integrated least-cost energy development plans and, where such plans do not exist, supporting the development of such plans; (2) promoting the efficient use of energy in all economic sectors; and (3) developing and carrying out regional energy integration programs.
- *World Bank* policy states that energy lending will be based on integrated least-cost energy plans, with emphasis on energy efficiency, demand-side management, and the exploitation of renewable-energy sources. The World Bank is also playing a major role in the GEF, where it is responsible for the majority of GEF investment operations to reduce greenhouse gas emissions.

The United States continues to urge the MDBs to increase their lending for and their staff positions in the areas of renewable energy and energy efficiency. The United States also encourages the banks to consider the impacts of their lending on global climate through the use of enhanced environmental impact assessments.

International Energy Agency

The IEA is an autonomous body established in 1974, within the framework of the Organization for Economic Cooperation and Development (OECD), to cooperate in energy matters and promote energy security. Increasingly, IEA member countries have come to see energy security not only in terms of ensuring an adequate energy supply for

themselves, but also in terms of seeing that the worldwide production and use of energy are environmentally sustainable over the long term.

To support its members in their commitments to reduce greenhouse gas emissions, the IEA is engaged in a growing number of activities related to climate change. These include a series of analytic studies on the interactions between energy and the environment, a Climate Technology Initiative and other agreements for the development and diffusion of climate-friendly technologies, and a long-standing program of multilateral cooperation to develop technologies that use renewable-energy resources, that produce cleaner energy from fossil fuels, and that use energy more efficiently.

Analytic Studies on Energy and Climate Change

The IEA's ongoing study on the Energy Dimensions of Climate Change is identifying the key factors that affect the impacts of energy production and use on emissions of greenhouse gases. Some of the policy options the study is examining are removal of subsidies and price distortions; taxes and charges to raise energy prices; accelerated introduction of lower-carbon and carbon-free technologies; voluntary agreements, standards, and labeling programs; joint implementation; and target-related tradable permits.

The IEA is also engaged in work to better understand the potential contributions that new and improved technologies may be expected to make to climate change mitigation in the transportation, power production, and buildings sectors.

Recently, the IEA and OECD have jointly produced a range of FCCC working papers on policies and measures for common action. These include studies of policies for reducing carbon dioxide emissions from road vehicles, reform of coal and electricity subsidies, full-cost pricing in energy markets, carbon and energy taxes, energy-efficiency standards for traded products, finance of energy efficiency in countries with economies in transition, and options for greenhouse gas reduction in agriculture and forestry.

Climate Technology Initiative and Related Agreements

Undertaken by a group of Annex 2 Parties to the FCCC and supported by the IEA and OECD secretariats, the CTI began by taking an inventory of activities in IEA/OECD member countries to promote climate-friendly technologies. This inventory should help to identify future areas for increased cooperation among countries with similar activities, as well as to alert new countries of possibilities for joining work underway. The CTI has since been expanding the scope of its activity through several task forces, with participation from the United States and other member countries.

The United States is taking a leading role in the CTI task force on Energy Technology Networking and Capacity Building, which is engaged in a broad array of activities to make reliable information on climate change technologies more accessible, to develop options for improving information centers and systems on climate change

technologies in developing countries, and to support the involvement of experts around the world in achieving these ends.

The United States is also actively involved in the CTI task force on Greenhouse Gas Capture, Removal, and Disposal. The work plan for this group includes cooperative activity on technologies for biological production of hydrogen fuel, chemical fixation and use of carbon dioxide, and land and ocean sequestration of carbon dioxide.

Apart from the CTI, several standing IEA implementing agreements provide for multilateral cooperation on greenhouse gas technologies.

- The Greenhouse Gas Technology Information Initiative (GREENTIE) aims to identify energy technologies that mitigate greenhouse gas emissions and have the potential for international deployment.
- The Center for the Analysis and Dissemination of Demonstrated Energy Technologies (CADET) was established to promote the use of available energy-efficiency technologies, but will soon be merged with GREENTIE.
- The Greenhouse Gas R&D Program is conducting full fuel-cycle analyses of conventional and advanced power-generation systems and evaluating novel strategies to reduce CO₂ emissions.

Asia-Pacific Economic Cooperation

In 1995-96, the United States contributed \$1.3 million to this ministerial-level agreement to promote the economic and social well-being of the Asia-Pacific region. The United States has the lead in the energy efficiency area, which focuses on workshops and seminars on energy-efficient technologies and practices, and develops programs for mitigating greenhouse gas emissions using energy technology. These programs emphasize training and information exchange, analysis of options and mutually agreed technology research and development.

An example of an activity with direct relevance to greenhouse gas abatement is the APEC Joint Multilateral Demonstration Project for the Recovery and Utilization of Coal Mine Gas, being carried out in the People's Republic of China. This is a three-phase effort to identify potential ways to improve environmental performance through expanded coal mine gas demonstration projects. The third phase will involve the design and engineering study for the construction of a demonstration facility.

Nongovernmental Efforts

The U.S. private sector is engaged in many important activities overseas, particularly in the areas of renewable energy and energy efficiency. Of equal importance for mitigating the threat of climate change are the efforts of U.S. industry to expand its

exports of climate-friendly technologies. The potential for technology transfer from the private sector dwarfs the ability of governments in this field. Following are some examples of U.S. private-sector activities related to climate change; the list is by no means exhaustive.

Edison Electric Institute

EI is the association of investor-owned electric utilities in the United States. In 1995, it set up a program called International Utility Efficiency Partnerships (IUEP), whose purpose is to identify opportunities to support joint implementation project investment and development activities, and to demonstrate utility commitment to voluntary approaches to global climate issues. IUEP currently has ten projects underway in nine countries, with over \$550 million in funding.

With support from fifty-five electric utilities, EI developed the Utility Forest Carbon Management Program to expand the industry's efforts to manage carbon dioxide through domestic and international forestry projects. The program's goals are to advance the state of knowledge regarding options for managing greenhouse gases via forestry, establish low-cost forestry options to manage greenhouse gases, and implement forestry projects.

The Alliance to Save Energy

Under its Sustainable Cities and other projects, the Alliance promotes energy-efficiency initiatives in Monterrey, Mexico; Kaliningrad, Russia; Lviv, Ukraine; Ghana; India; and China. These initiatives are designed to fit the needs of each region--from promoting municipal energy policy changes, to leading trade missions that foster energy-efficiency awareness, to developing an overseas office.

U.S. Export Council for Renewable Energy

US/ECRE offers training programs through its member trade associations, as well as the Renewable Energy Training Institute. RETI was established to match international requests for education and training with qualified, experienced U.S. instructors and institutions. US/ECRE also facilitates training sessions at multilateral development banks, commercial banks, and private foundations to familiarize them with renewable-energy and energy-efficiency products and services.

Export Council for Energy Efficiency

ECEE is a consortium of five of the country's leading advocates of energy efficiency. Its mission is to expand exports of energy-efficiency products and services by leading trade missions, identifying financing, and connecting U.S. companies with foreign buyers. ECEE and US/ECRE are jointly engaged in an Asia-Pacific Initiative, under which

ECEE has, for example, published a market assessment of the opportunities for energy efficiency in Indonesia and organized training workshops in the Philippines.

International Institute for Energy Conservation

IIEC seeks to accelerate the adoption of energy-efficient policies, technologies, and practices in developing countries and countries with economies in transition. It acts as a facilitator between institutions with experience implementing energy-efficiency programs and those institutions in developing countries with the need for such expertise. IIEC is a close partner of both the U.S. Country Studies Program and EPA.

American Council for an Energy-Efficient Economy

For over a decade, ACEEE has worked with Brazil to establish a national electricity conservation program, as well as a National Institute for Energy Efficiency modeled on ACEEE's activities.

Rebuild America (Climate Plan Action 1)

This action is part of DOE's Commercial Buildings Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$2.8 billion
- Energy savings of 0.42 quads
- Carbon-equivalent savings of 8.8 MMT

By accelerating cost-effective, energy-efficient investments in public housing, and in commercial and multifamily buildings, Rebuild America partnerships are expected to cut energy bills significantly, create local jobs, improve environmental quality, and provide more comfortable indoor environments that enhance the quality of life and worker productivity. For example, in the year 2000, Rebuild America partnerships plan to retrofit 2 billion square feet of commercial and housing floor space. This would put \$3 billion into local economies and create \$650 million in annual energy savings for building owners and occupants in the near future.

Partnerships are based on local needs and priorities, which provides community leaders a high level of flexibility in designing their Rebuild America programs. Any assembly of companies and organizations that commit to a community focus may form Rebuild America partnerships. Partners receive a customized set of products and services designed to meet their community's special needs as well as national recognition for innovative approaches to

community-wide programs. A Rebuild America program representative works with the partners' team to ensure that timely and effective assistance is provided.

Achievements

As of March, 1997, Rebuild America is working with over 120 communities representing 38 states and territories.

- Rebuild Boston is incorporating water and energy efficiency into community enterprise zones.
- Kansas City Energy Efficiency Partnership is improving energy efficiency in schools and nonprofits over the bi-state, five-county metropolitan area.
- Re-energize East Bay is dramatically increasing the penetration of energy-efficiency technologies into the often overlooked small commercial market in the San Francisco Bay area.
- Rebuild Colorado is increasing the energy efficiency of the state's commercial and government buildings through performance contracting.

During the December 1996 Rebuild America Fall Forum, partners were enthusiastic about their achievements and about the success of the program in general. For example, through the Tennessee Department of Economic and Community Development, Rebuild Tennessee is targeting communities with 17,000 people or fewer--particularly small businesses--to achieve an estimated 30 percent energy cost savings per building retrofitted.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Green Lights[®] & ENERGY STAR[®] Buildings (Climate Plan Actions 1 & 2)

The Climate Change Action Plan expanded the Green Lights program. In the year 2010, the full Green Lights and ENERGY STAR Buildings programs are expected to generate:

- Energy cost savings of \$11.3 billion
- Energy savings of 1.5 quads
- Carbon-equivalent savings of 23.9 MMT

EPA's Green Lights[®] and ENERGY STAR[®] Buildings programs are designed to improve the energy efficiency of commercial and industrial buildings. These buildings account for over 15 percent of all U.S. energy consumption, contributing significantly to

greenhouse gas emissions and other air pollution. This pollution can be reduced through energy-efficiency investments that also reduce energy bills.

Green Lights

Through the voluntary Green Lights program, EPA overcomes informational and other barriers preventing energy-efficiency investments. Green Lights partners are reducing their lighting energy consumption through cost-effective, energy-efficient lighting technologies. On average, investments in these technologies cut electricity consumption in half and provide a 35 percent rate of return due to the significant energy bill savings. EPA provides technical information and support and environmental recognition to participants who adopt these voluntary and profitable energy-efficiency measures. Because lighting accounts for 35 percent of total electricity consumption in buildings, Green Lights has a substantial overall impact on U.S. energy consumption and greenhouse gas emissions.

ENERGY STAR Buildings

Expanding on the successful Green Lights program, EPA works with individual building owners, developers, and others through its voluntary ENERGY STAR Buildings program to encourage more comprehensive building upgrades. This program leads a building owner through a five-stage strategy to capitalize on system interactions that maximize energy savings at minimum cost. Green Lights is the first step of this strategy. EPA has successfully completed the ENERGY STAR Showcase Buildings program, in which charter partners demonstrated an average building-wide energy savings of 30 percent.

Achievements

The Green Lights and ENERGY STAR Buildings programs currently have over 2,300 participants, including small and large businesses, universities, and state and local governments.

- Partners have already invested \$1 billion on energy-efficiency improvements, with commitments for much larger investments in the near future.
- Partners are saving over \$300 million a year on their energy bills.
- Partners are preventing 700,000 metric tons of carbon-equivalent pollution annually, equivalent to eliminating the emissions from over 500,000 cars.

Contacts: EPA's ENERGY STAR Hotline, 1-888-782-7937 (Domestic) or 202-775-6650 (International)

Construction of Energy-Efficient Buildings (New Climate Plan Action)

In the year 2010, this initiative is expected to generate:

- Energy cost savings of \$0.5 billion

- Energy savings of 0.1 quads
- Carbon-equivalent savings of 1.1 MMT

The Rebuild America and ENERGY STAR Buildings programs are effectively improving the energy efficiency of existing commercial and industrial buildings. Additional, long-term energy savings and greenhouse gas reductions can be achieved by improving the energy efficiency of new commercial and industrial buildings. By 2010, one-fifth of all energy consumption in commercial and industrial buildings is projected to be from buildings that are built after 2000. Through this joint initiative, DOE and EPA will expand their voluntary programs in the buildings sector by promoting energy efficiency in the construction of new 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 perpetuate 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.

DOE and EPA will work with builders, architects, owners and operators, and the financial community to encourage and recognize the construction of energy-efficient buildings. Working with these industries, DOE and EPA will develop a system to differentiate buildings that offer energy cost savings from typical, inefficient buildings. Rebuild America has already begun working with the American Institute of Architects and many other partners to reach these goals. ENERGY STAR Buildings has developed an energy-efficiency building program that currently focuses on retrofits to existing buildings. Under this action, the agencies will jointly develop a program that most effectively improves energy use in new buildings.

Contacts: DOE's Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International). EPA's ENERGY STAR Hotline, 1-888-782-7937 (Domestic) or 202-775-6650 (International).

Cost-Shared Demonstrations of Emerging Technologies (Climate Plan Action 4)

This action is part of DOE's Lighting and Appliance Research and Development Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$3.1 billion
- Energy savings of 0.44 quads
- Carbon-equivalent savings of 9.3 MMT

DOE has longstanding experience working in collaboration with appliance and equipment manufacturers and distributors to promote the development of innovative, energy-conserving building equipment. Performance testing and new-product evaluation in commercial buildings are two of several areas enhanced through cost-shared demonstrations. DOE's cost-shared demonstration programs seek to achieve benefits primarily through reduced energy consumption for building appliances and HVAC (heating, ventilating, and cooling) systems.

By organizing projects that bring together manufacturers and prospective purchasers to test and evaluate prototype equipment, DOE expects to reduce the market risk perceived by the developer of new technology and provide users the opportunity to influence final design decisions. The result is greater investment in new, energy-efficient products, more rapid introduction of those products to the marketplace, and fewer failures of commercial introductions.

To achieve continuity and better coordination in its demonstrations, DOE has formed partnerships with groups of industrial and commercial firms having the potential to put emerging technologies to use. These Technology Partnerships include a consortium of hotel/motel chains and the National Association of Energy Service Companies.

Achievements

- Through a consortium of the hotel/motel industry, representing over 30 percent of U.S. hotel space, DOE and Red Lion Inn hotels demonstrated a new energy-saving system for large central laundries that allows reuse of hot laundry wash water.
- DOE and the U.S. Postal Service have embarked on a major demonstration of sulfur lamps, to introduce this technology to other similar facilities. Aircraft hanger lighting demonstrations are planned for Hill Air Force Base.
- Successful demonstrations of the "horizontal-axis" clothes-washing machines have prompted DOE and Maytag to demonstrate the water and energy savings of this beneficial technology to a small town that has severe water problems. Under a cooperative research and development agreement with Maytag and Oak Ridge National Laboratory, Maytag will replace washers in 90 homes throughout Bern, Kansas. To promote the environmental benefits of this technology in areas with severe water problems, DOE received co-funding from the Bureau of Reclamation that will be used to compare the energy and water consumption of the existing and new washers.
- DOE and the National Association of Energy Service Companies are improving the effectiveness of performance contracting as a means of introducing energy-efficient technology to the commercial sector.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

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

This initiative is part of DOE's Best Practices Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$1.2 billion
- Energy savings of 0.19 quads
- Carbon-equivalent savings of 3.9 MMT

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 assist in maintaining knowledge about energy-efficiency improvements for a highly transitory career field. DOE also draws upon the experience of the Federal Energy Management Program, that of state energy offices, low-income weatherization providers, utilities, and other successful programs currently underway, such as Rebuild America.

Achievements

- Surveyed existing programs and the successes and measures that have been used to evaluate training program effectiveness.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

**ENERGY STAR[®] Products
(Climate Plan Action 6)**

The Action Plan expanded the ENERGY STAR Products program. In the year 2010, the full program is expected to generate:

- Energy cost savings of \$10.2 billion
- Energy savings of 1.2 quads
- Carbon-equivalent savings of 23.7 MMT

DOE and the EPA are working to bring high-efficiency consumer products into American households and buildings. Products include those used for space heating and cooling, water heating, lighting, refrigeration, laundering, cooking, and other services.

Working with equipment manufacturers, DOE and EPA are using the ENERGY STAR[®] label to promote highly efficient products. Consumer education is an important part of the labeling activities. A national consumer education campaign is being developed to educate consumers about the important link between energy use and the environment.

With the ENERGY STAR label, consumers will be able to easily identify products that save energy and money and help the environment. DOE has launched “ENERGY STAR Retailer” to further promote efficient products through point-of-purchase information, product labeling, sales force training, and corporate advertising.

Collaboratives formed with DOE are facilitating the development of initial markets for advanced technologies, for example, by encouraging large purchases. Large-volume purchases help reduce manufacturing costs through economies of scale in initial production.

Achievements

- Consumers and businesses prevented over one million metric tons of carbon-equivalent pollution in 1996, and saved over \$400 million on energy bills due to ENERGY STAR equipment.
- Over 500 manufacturers are currently participating, offering over 13,000 product models that qualify for the ENERGY STAR label.
- Four major utilities have joined the program to promote ENERGY STAR appliances with retail chains in utility service territories.
- Over 920 retail stores now label ENERGY STAR refrigerators, dishwashers, and room air conditioners.
- Public housing authorities, including the New York Public Housing Authority, are about to purchase over 70,000 high-efficiency refrigerators for their apartment complexes.
- More than 70 builders and developers have committed to build over 10,000 ENERGY STAR Homes across the United States.

Contacts: DOE’s Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International); EPA’s ENERGY STAR Hotline, 1-888-782-7937 (Domestic) or 202-775-6650 (International).

Residential Appliance Standards (Climate Plan Action 7)

This action is part of DOE’s Lighting and Appliance Standards Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$7.4 billion
- Energy savings of 0.96 quads
- Carbon-equivalent savings of 21.6 MMT

Residential consumers spend \$110 billion each year on home appliances and equipment, such as refrigerators, water heaters, and air conditioners. As this equipment is replaced, large savings opportunities are available from the purchase of high-efficiency equipment. The Energy Policy Act of 1992 directs DOE to develop mandatory energy-efficiency standards for residential appliances. DOE must review these standards in accordance with a statutorily set schedule to determine whether the standards are stringent enough. Energy and carbon emission reductions from this action will be a direct result of more stringent appliance efficiency standards.

The Residential Appliance Standards program creates higher energy-efficiency levels for eleven product categories of residential appliances. The program enlists the participation of manufacturers, trade associations, environmental groups, utilities, government agencies, residential appliance retailers, and others in public rulemaking processes to set these new standards.

Achievements

- Three-Product Rulemaking--In September 1993, DOE published an Advance Notice of Proposed Rulemaking in the Federal Register regarding energy-conservation standards for central air conditioners and heat pumps; furnaces; and refrigerators, refrigerator-freezers, and freezers. The three-product rule has since been amended into three separate rules. The standard, which applies to refrigerators, refrigerator-freezers, and freezers, was published in July 1995.
- Clean Three Rulemaking--DOE has conducted analyses on clothes washers, clothes dryers, and dishwashers and held a workshop in July 1995 to discuss the results with stakeholders.
- Eight-Product Rulemaking--The eight-product rule was divided into several separate rules. One rulemaking applies to room air conditioners, gas and oil water heaters, direct heating equipment, kitchen ranges and ovens, mobile home furnaces, and pool heaters. A proposed television rule has been withdrawn.
- A congressional moratorium imposed on new standards during 1996 has ended. DOE expects to issue final rules for improved efficiency standards for refrigerators and room air conditioners in 1997. An Advanced Notice of Proposed Rulemaking for clothes washers is also due out in 1997.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Energy Partnerships for Affordable Housing (Climate Plan Actions 8 & 11)

This initiative is part of DOE's Residential Buildings DOE's Residential Buildings Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$0.4 billion
- Energy savings of 0.06 quads
- Carbon-equivalent savings of 1.2 MMT

Energy Partnerships for Affordable Housing is designed to improve the energy efficiency and affordability of public and privately owned single-family and multifamily housing for low- to moderate-income families throughout the nation. Its main goal is to create local and community partnerships that will collectively commit to installing energy-efficiency improvements in at least one million low-income housing units by the year 2000.

Begun as a joint initiative between DOE and the Department of Housing and Urban Development, the program establishes voluntary collaborations with state and local governments, utilities, and the housing development and financing industries that can provide resource-efficient and affordable housing in new and revitalized 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 showcase and promote efficient whole-building design scenarios throughout their communities; and (3) close collaboration with retailer program efforts to foster appliance efficiencies. The partnership also works with those who establish guidelines for Home Energy Rating Systems.

Program goals are expected to be reached by making technical assistance available to community-based housing providers for the application of whole-building design and rehabilitation specifications that can achieve 20 to 30 percent efficiency gains over current practice. DOE and the National Association of Housing and Redevelopment Officials have united under DOE's Energy Partnerships for Affordable Housing program.

Achievements

- DOE initiated partnerships with public housing authorities and community housing organizations in Chicago, Atlanta, Boston, Baltimore, and Los Angeles, with one goal being a 30 percent reduction in utility bills.
- DOE, EPA, and Habitat for Humanity are working together to improve the energy and resource efficiency of the over 3,000 homes Habitat has built in the United States.
- DOE is funding seven states (AK, AR, CA, CO, MI, VT, and VA) to overcome the barriers to the use of energy-efficient mortgages.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Cool Communities (Climate Plan Action 9)

This initiative is part of DOE's Building Systems Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$1.0 billion
- Energy savings of 0.15 quads
- Carbon-equivalent savings of 2.9 MMT

Cool Communities aims to reverse problems associated with urban heat islands by developing community partnerships to create a market for highly reflective exterior surfaces on buildings and roads, in combination with urban tree planting as a cost-effective energy-efficiency measure.

Private-sector involvement in Cool Communities is an integral part of the program. The nonprofit conservation organization American Forests is DOE's and the U.S. Forest Service's primary partner in this program. Utility companies, through their participation in the Climate Challenge program, also are partners. Roofing, pavement, coatings, and landscaping industries, as well as other federal agencies participate in product development and marketing.

Overall Achievements

- As of March 1997 there are 10 designated Cool Communities.
- In its next revision, the National Energy Performance Standards for Buildings (American Society of Heating, Refrigeration and Air-Conditioning Engineers) will give energy-conservation credits for cool roofs and shade trees. Similar credits will be offered in the California Title 24 building standard.
- South Coast Air Quality Management District in California accepted Cool Communities strategies as the most cost-effective single measure in the reduction of smog. Consideration is being given to include "cool" technology in a NO_x and smog offset trading market.
- The American Society for Testing and Materials is standardizing procedures for rating roofs and pavements for reflectivity. A new "Solar Reflectance Label" will help consumers evaluate the energy efficiency of cool products.

Selected Community Achievements

- Austin, Texas--Initiated "Trees for Energy," in which utility companies, landscaping industry professionals, and local government officials collaborated on incentive rebates for planting community trees.
- Atlanta, Georgia--Broadcasts heat-island reports on the evening weather and used the 1996 Summer Olympics to publicize demonstrations of Cool Communities technologies.

- Frederick, Maryland--Estimates energy savings of \$1 million annually from existing trees and roofs, with a potential tripling of savings by using more “cool” technologies.
- Dade County, Florida--Is raising funds from the state’s sale of panther and manatee license plates to reestablish trees destroyed by Hurricane Andrew.
- Davis-Monthan Air Force Base in Tucson, Arizona--Was awarded the Federal Energy Efficiency Landscape Award for Cool Communities accomplishments.
- National Air Station, Oceana--Is planning tree-planting, pavement, and roofing projects.

Contacts: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International); Rita Schoeneman, USDA, Forest Service, Cooperative Forestry, 202-205-1612.

Updating State Building Codes (Climate Plan Action 10)

This action is part of DOE’s Building Standards and Guidelines Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$4.0 billion
- Energy savings of 0.55 quads
- Carbon-equivalent savings of 12.7 MMT

Updating and implementing building energy codes is often the most cost-effective means of overcoming market barriers to energy efficiency. These codes eliminate inefficient construction practices and technologies at little to no increase in first cost and significant energy cost savings.

DOE provides technical and financial support to states in updating and implementing the energy-efficiency provisions of their codes. Competitive, cost-shared, incentive grants are provided to assist states in leveraging their own programs and those of their utility and building industry partners to update their codes and train code officials, designers, and builders in how to use them. DOE develops materials and tools to make energy codes easier to use and administer, and disseminates them to the states. DOE also develops core training materials and fosters industry partnerships with states to carry out training.

DOE’s goal is to reduce total emissions and energy use in new buildings by 35 percent by the year 2000, from 1990 levels.

Achievements

- Twenty-seven states have adopted and implemented residential energy codes that meet or exceed the 1992 Model Energy Code. These state codes govern 54 percent of U.S. residential construction.
- Twenty-five states have adopted and implemented commercial building energy codes that meet or exceed the building industry consensus energy code, ASHRAE/IESNA 90.1-1989. These state codes govern 61 percent of U.S. commercial construction.
- Over 1,000 architects, engineers, builders, and code officials have been trained in how to comply with updated state codes.
- DOE has developed a set of materials and tools that make it easy to design and build to the Model Energy Code. Called MECcheck, this set has been disseminated to over 10,000 people in 20 states.
- A parallel set of materials, COMcheck-EZ, has been developed for low-rise commercial buildings (three stories or fewer), which comprise the majority of U.S. commercial building.
- DOE has formed partnerships with a number of product manufacturers to assist states in training designers and builders.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Superwindow Collaborative (New Climate Plan Action)

This initiative is part of DOE's Windows and Glazings Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$0.8 billion
- Energy savings of 0.11 quads
- Carbon-equivalent savings of 2.3 MMT

DOE's Superwindow Collaborative is expected to double the energy efficiency of the average window sold in 2005. In achieving its goals, the collaborative is expected to improve the thermal properties of the windows sold in terms of both their heating and cooling energy properties: reducing the average U value of windows sold from 0.65 to 0.25 in heating climates, and switching from clear to spectrally selective cool glazings in the southern part of the country.

Every year residential windows in the United States are responsible for about 2.0 quads of energy use and 40 MMTCE. If all residential buildings used currently available--but not extensively deployed--high-performance window technologies, annual window

energy use could be reduced by 1.2 quads, and annual carbon emissions by about 18 MMT. Certain fundamental constraints limit the achievement of this technical potential: (1) the window-selection and -specification process, by which end users (e.g., home owners, builders, renovators, and architects) are capable and motivated to choose the energy-efficient window technologies; and (2) the availability of high-performance glazing and window technologies and the ability of the industry to produce such technologies at affordable prices and in adequate volumes.

As an offshoot of one of DOE's buildings research programs, the Superwindow Collaborative supports highly leveraged industry-user-government teams in transforming the market and industry toward production and use of energy-efficient windows.

Another industry team will be coordinated through the Primary Glass Manufacturers Association. Growth in market penetration of Low-E and other high-energy-performance windows has slowed and is now about one-third of the market. DOE-industry teams will work to re-accelerate this growth to more than double the penetration of high-energy-performance window systems. These teams will strive to upgrade their specific technologies--e.g., vinyl windows and glass-coating processes and technologies.

Superwindow Collaboratives will produce and provide tools and information products for window manufacturers, along with detailed training by producer and user teams.

Some of the private- and public-sector partners DOE will be collaborating with are the National Fenestration Rating Council, utilities, window component manufacturers, glass manufacturers, window system manufacturers, states, retailers, and the architect-engineer community.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Motor Challenge (Climate Plan Actions 12 & 13)

In the year 2010, Motor Challenge is expected to generate:

- Energy cost savings of \$0.34 billion
- Energy savings of 0.07 quads
- Carbon-equivalent savings of 5.8 MMT

Since electric motor-driven system applications account for more than 70 percent of U.S. industrial energy consumption, Motor Challenge is geared at harnessing the tremendous potential energy cost savings that will accrue once system inefficiencies are identified and reduced. Motor Challenge is a voluntary partnership program between DOE and industry to promote the adoption of a systems approach to developing, purchasing,

and managing motors, drives, and motor-driven equipment, thereby increasing energy efficiency, enhancing productivity, and improving environmental quality.

Motor Challenge is comprised of four integrated program elements: Industry Partnerships (trade associations and industry groups); Allied Partnerships (non-end-user companies, along with suppliers, distributors, utilities, etc.); Excellence Partnerships (end-user industrial companies); and Showcase Demonstrations (technically focused projects at industrial plants). These partnerships aim to develop and deliver new tools, information, best practices, and industry case studies to assist manufacturers in making more informed management decisions about motor-driven systems.

In addition to program elements, Motor Challenge offers numerous products and services. These include MotorMaster Plus, an electric-motor decision and management software tool; a periodic newsletter, Turning Point; showcase demonstration project case studies; pumping system optimization workshops; and the Information Clearinghouse, which maintains the Motor Challenge Web Page (<http://www.motor.doe.gov>) and responds to partner inquiries.

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 projects using technology and engineering to optimize electric motor systems.

Achievements

- The Motor Challenge program was officially launched in October 1993, with 44 organizations designated as Charter Partners.
- As of June 1997, 2,000 organizations had enlisted with over 125 Allied Partners (suppliers, distributors, utilities, and state agencies) who are disseminating Motor Challenge products, tools, and software to thousands of industrial end users.
- The Information Clearinghouse has responded to over 800 calls a month requesting information and technical assistance. More than 250 downlink sites with an audience of over 8,000 viewed the "Efficient Motor Systems: Strategies for Success" teleconference on May 23, 1995.

DOE has completed 10 showcase demonstrations, and has 15 ongoing projects representing an industry investment of \$10 million. The estimated annual energy savings represents 100 million kilowatt-hours a year, or the equivalent amount of electricity supplied to over 5,000 homes a year.

Contact: Motor Challenge Information Clearinghouse, 1-800-862-2086 (Domestic) or 703-287-8391 (International).

Industrial Assessment Centers

(Climate Plan Action 15)

In the year 2010, Industrial Assessment Centers (IACs) are expected to generate:

- Energy cost savings of \$0.4 billion
- Energy savings of 0.08 quads
- Carbon-equivalent savings of 1.9 MMT

Over 80 percent of industrial energy is consumed by manufacturing. Smaller manufacturing firms rarely have in-house expertise or staff to address energy-efficiency and waste-minimization improvements.

Since 1976, DOE has sponsored energy audits for small- and medium-sized manufacturers. Conducted by the IACs at 30 universities across the country, these audits provide recommendations to help manufacturers control costs and improve energy efficiency.

In addition to evaluating industrial energy use, IACs make recommendations for minimizing wastes and for improving productivity, and conduct energy-productivity and waste-reduction analyses. Under the IAC program, teams of engineering faculty and students perform the industrial assessments. Each school completes approximately 25 assessments a year for plants within a 150-mile radius of its campus. Partnering plants must be in compliance with standard industrial codes 20-39, must have gross sales below \$75 million at the plant site, must employ fewer than 500 people, must have a utility bill of \$75,000-\$1,750,000, and must lack the technical skill to perform the assessment on their own.

Achievements

- Since 1976 the program has conducted over 7,000 energy assessments.
- Approximately 2,100 students who have participated in the program through their university have received energy-efficiency and waste-management training. This experience gives them access to better opportunities upon graduation.
- Via the Internet, utilities, manufacturing firms, and the general public may access IAC results and recommendations from a data base that holds the results of all assessments since 1981.
- A training manual and “Self Assessments” workbooks were produced for both small and large plants. These materials are available on the Internet at <http://www.oit.doe.gov/access.iac.html>

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

NICE³
(Climate Plan Action 16)

In the year 2010, NICE³ is expected to generate:

- Energy cost savings of \$0.4 billion
- Energy savings of 0.09 quads
- Carbon-equivalent savings of 2.1 MMT

National Industry Competitiveness Through Energy, Environment, and Economics (NICE³) promotes innovation, energy efficiency, clean production, and economic competitiveness in industry through one-time matching grants of up to \$425,000. The program funds state and industry partnership proposals that will develop and demonstrate advances in energy-efficiency and clean-production technologies.

Successful projects demonstrate industrial applications of energy-efficient technologies that reduce costs to industry and prevent pollution in the manufacturing sector, with emphasis on the aluminum, chemicals, forest products, glass, metal casting, petroleum refining, and steel sectors. They identify and implement efficiency improvements in material inputs, processes, and waste streams to enhance U.S. industrial competitiveness. The total federal value of current projects is at least \$20 million, with an average private cost share of \$3.68 of private investment per federal dollar.

Achievements

- With fiscal year 1996 funds, 17 projects were funded in 15 states, with \$6.2 million in federal funds and \$12.0 million co-funded by each state-industry partnership to produce the next wave of cost-effective, pollution-prevention technologies that will spawn further innovation as project successes come to fruition.
- As a result of NICE³, Caterpillar demonstrated to over 90 attendees at an open house that paint sludge from water-washed overspray could be recovered and recycled. While continuing to use the technology in-house, Caterpillar is also negotiating with potential vendors to market the technology to industry, thus potentially exceeding the energy and environmental benefits originally projected.
- Beta Corporation of Oregon, a small business, has sold approximately 20 units of its Hydrochloric Acid Recovery System, a closed-loop, on-site recovery system for galvanizers and small- to medium-sized steel manufacturers.
- Pegasus Technologies Neural Networks has sold several installations of its Real-Time Neural Networks for Combustion Optimization system. The computerized monitoring system optimizes combustion settings for minimal NO_x and reduced SO₂ and CO₂ emissions, while simultaneously maintaining or improving plant thermal efficiency. These installations have saved over one trillion Btus of energy.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

WasteWi\$e (Climate Plan Action 16)

EPA's WasteWi\$e program encourages businesses to set voluntary waste-prevention and -recycling goals that they can achieve cost-effectively. The businesses agree to report on progress toward achieving those goals. The Pay-As-You-Throw program (PAYT), on the other hand, encourages communities and municipalities to consider charging for waste disposal according to weight or volume. PAYT is a proven financial incentive for citizens to reduce and recycle their waste.

EPA source-reduction and recycling efforts are intended to reduce greenhouse gas emissions by (1) reducing methane emissions from the decay of waste in landfills, (2) increasing carbon sequestered by forests, and (3) reducing emissions resulting from extracting and processing virgin materials and manufacturing products. Beyond emission reductions, additional benefits include preservation of natural resources from reduced extraction and processing of virgin materials; reduced waste disposal; reduction in air, water, noise, and other pollution associated with waste disposal and manufacturing; reduced costs of municipal solid waste management; and jobs and income created by new recycling enterprises.

Achievements

- After only three full years of operations, WasteWi\$e boasts over 535 business partners who are reducing and recycling increasing quantities of waste. While 1996 results are not yet available, in 1995 WasteWi\$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. WasteWi\$e is opening membership to tribal, state, and local governments for the first time in 1997.
- Program highlights in 1996 included completion and distribution of a PAYT Tool Kit (containing, among other things, a guide and workbook for determining how to establish rates for household trash disposal) and completion of a digital spreadsheet for use by solid waste planners in developing rates to charge for waste disposal. Also in 1996, significant progress was made in completing a comprehensive training video on Pay-As-You-Throw for use by solid waste planners. As of the end of 1996, EPA estimates over 3,000 Pay-As-You-Throw programs are in place nationwide.

Contact: Clare Lindsay, EPA, Office of Solid Waste, 703-308-7266.

Improve Efficiency of Fertilizer Nitrogen Use

(Climate Plan Action 17)

Improving the efficiency of fertilizer use will result in lower emissions of nitrous oxide (N₂O) from microbial activity occurring in the soil and lower CO₂ emissions from electricity and natural gas consumption during the manufacture of fertilizer. The program is expected to expand activity to develop models that focus on trace gas exchange related to the bacterial nitrification and denitrification processes. These models will be used to improve the efficiency of nitrogen use, while maintaining an efficient and productive agricultural system. Demonstration projects and an information campaign will ensure widespread application of improved management practices.

Achievements

- Extensive collection of data from farmers' fields has been completed for testing the USDA Agricultural Research Service's NLEAP model for determining the efficiency of nitrogen use. Comparisons show efficiencies in small grain > potatoes > lettuce. Rotations of small grains with potatoes and lettuce, and proper management of irrigation, increase efficiencies in these systems. Wheat and rye, when used as winter cover crops, mitigate nitrogen losses by scavenging nitrogen lost from the shallower root systems of lettuce and potatoes. The scavenger winter-cover crops protect water and soil quality by reducing wind erosion and increasing the cycling and efficient use of nitrogen. NLEAP is a technology-transfer management tool capable of evaluating the effects of sequential crops on water quality and on the cycling and efficient use of nitrogen.
- The NLEAP model was extended to predict N₂O emissions from agricultural soils under a range of management and weather conditions. Field testing of the model in Colorado has shown that simulated N₂O losses are consistent with measured values. A prototype version of the model has been delivered to USDA's Natural Resources Conservation Service (NRCS) for field testing nationally. Joint Agricultural Research Service research is continuing to evaluate and apply the model nationwide.
- Of the 18 demonstration projects NRCS established in 1995, four continue to receive funding for substituting organic sources of nitrogen (e.g., legume cover crops or manure) for commercial nitrogen fertilizer and alternative methods of manure application to maximize nutrient utilization by plants.
- NRCS is evaluating nitrogen management systems for corn, cotton, potatoes, and rice that minimize gaseous emissions of N₂O with the model NLEAP. Ten states are currently participating. NRCS will create a data base of this information for its conservationists in the field and for others who provide nutrient management planning assistance to farmers.

Contacts: Ron Follett, USDA, Agricultural Research Service, 970-490-8200; Charles Lander, USDA, Natural Resources Conservation Service, 202-690-0249.

Transportation Partners (Climate Plan Action 20)

This initiative is intended to reduce the growth in vehicular travel through voluntary adoption of local and regional transportation strategies that provide better, cheaper, and more numerous transportation choices for citizens. These strategies are (1) community design or redevelopment measures that encourage walking, biking, and transit; (2) market-based measures that, for example, reduce parking subsidies or transmute them into transit benefits, or that increase the cost of peak-hour travel relative to nonpeak travel; and (3) applications of telecommunications and other technologies that can eliminate the need to travel (telecommuting or teleservices), or that increase the market viability of transit.

Transportation Partners promotes the voluntary efforts of citizens and elected officials to develop innovative transportation projects and plans that address transportation needs, economic growth, environmental quality, and equity. The highly decentralized program encourages and recognizes local commitments to better transportation systems and provides a wide range of technical, strategic, and outreach assistance to ensure effective implementation.

The travel reductions that will be achieved by local partners brought into the program in its initial year are currently being estimated but are at least in the tens of millions of miles per year. A current program priority is implementing an ongoing evaluation strategy that will more precisely assess emission reductions achieved by this program. The benefits of Transportation Partners are expected initially to accrue slowly after the program's 1995 implementation and grow exponentially over the next several years.

Achievements

- Transportation Partners recruited 291 Project Partners working to improve local environments and transportation systems.
- The Principal Partner Local Government Commission held two major regional conferences on transportation for livable communities, which attracted over 1,000 participants.
- EPA's first annual "Way to Go!" awards were presented to eight outstanding local transportation innovators from the public and private sectors.
- The Transportation Action Network ("TransAct"), a comprehensive electronic information and assistance service, was launched by the Principal Partner Surface Transportation Policy Project. TransAct provides activists and transportation professionals with Internet access to a wide range of resources and peer contacts. See www.transact.org.

- The program co-sponsored the 1996 Rail~volution Conference in Washington, D.C., which was attended by over 600 civic representatives, transportation professionals, and developers. This annual conference has become the principal annual meeting for promoters of progressive transportation solutions at the local and national levels.

Contact: Paula Van Lare, EPA, Energy & Transportation Sectors Division, 202-260-3729.

National Telecommuting Promotion (Climate Plan Action 21)

Both the National Performance Review (NPR) and the Climate Change Action Plan (CCAP) identify telecommuting as a possible means to reduce traffic congestion, air pollution, greenhouse gas emissions, energy consumption, and accidents. The U.S. Department of Transportation (DOT) was designated the lead agency under the NPR and CCAP to promote and evaluate telecommuting in the federal government and in state and local agencies and the private sector.

Achievements

- Created a specialized training program and training materials on telecommuting for DOT supervisors and managers.
- Inaugurated the National Telecommuting Initiative, designed to implement new telework programs in up to 30 metropolitan areas.
- Initiated development of promotional campaign and field visits to states and federal regional offices to provide support in launching new telecommuting programs.
- Initiated research on successful telecommuting programs in the public and private sectors, and work on publicizing information on telecommuting, as mandated by Congress in the DOT appropriations legislation for fiscal year 1996. A report on successful programs will be generated.
- Initiated development of the Telecommuting Planning Manual for state and local agencies, which was completed in June 1997.

Contact: DOT, Office of the Assistant Secretary for Transportation Policy, 202-366-4813.

Seasonal Gas Use for the Control of NO_x (Climate Plan Action 24)

EPA promotes seasonal switching toward the use of low-carbon natural gas--particularly in the summer--in utility coal and oil plants and in industrial facilities. This innovative, low-cost strategy is expected to reduce carbon emissions and NO_x emissions

(which contribute to smog formation). The action is tied to rules and guidance issued in response to NO_x Reasonable Available Control Technology (RACT) requirements, the Economic Incentive Program, and State Implementation Plans related to National Ambient Air Quality Standards attainment under Title I of the Clean Air Act. EPA is working to encourage the use of natural gas through incentive-based, innovative programs that allow for less costly control strategies and provide stronger incentives for the development and implementation of innovative emission-reduction technologies.

Achievements

- EPA has continued the policy established in a guidance document that promotes the summer use of natural gas in utility coal and oil plants and in industrial facilities as a NO_x-reduction strategy.
- Twelve states in the Northeast and the District of Columbia (the Ozone Transport Region--) adopted a memorandum of understanding committing to a significant reduction in NO_x emissions from large sources (especially electric utilities) beyond RACT requirements. Utilities may comply with NO_x requirements by switching to natural gas during the summer.

Contact: Tracy Terry, EPA, Air and Energy Policy Division, 202-260-2875.

Renewable Energy Commercialization--Biomass (Climate Plan Action 26)

This initiative is part of DOE's Biomass Power Research and Development Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$0.9 billion
- Energy savings of 0.43 quads
- Carbon-equivalent savings of 8.9 MMT

New renewable-energy capacity of nearly 175 megawatts by the year 2001 is expected as biomass gasification demonstrations succeed and rural development proposals ensue. With twice as many partners as projected, DOE's Biomass Program is realizing the potential that near-term demonstration of integrated biomass power systems can have on technology deployment.

In addition, DOE's rural collaborative efforts are addressing the need for growing and harvesting dedicated energy feedstock for electricity generation. By using renewable, domestically produced biomass feedstocks, these systems can provide positive economic and environmental benefits over traditional fossil-fuel-based energy options. And as baseload and intermediate-load power-production options, these systems have great market-penetration potential, with the ability to compete in the largest segment of the U.S. electric utility market.

The major elements of this program include the Biomass Power for Rural Development initiative, a collaborative of DOE, USDA, and two advanced technology demonstrations--the Vermont Gasifier Project and the Hawaii Biomass Gasifier Facility--both of which involve the evaluation of advanced gasification/gas turbine systems.

Achievements

- In 1993, 10 private-sector consortia were formed.
- In December 1994, DOE, in collaboration with USDA, issued a request for proposal for integrated biomass power demonstration projects. DOE received more than 350 requests for the solicitation. In response, private-sector consortia, representing more than 100 organizations from 25 states, proposed a total of 1,000 megawatts of biomass-generating capacity and the dedication of up to 250,000 acres to biomass energy feedstock production. The three proposals selected through this competitive process will demonstrate cost-competitive, renewable biomass electricity generation from dedicated energy feedstocks by 2001. In total, these three projects will generate over 150 megawatts.
- The Vermont Gasifier Project will operationally demonstrate high-efficiency, “indirect” biomass gasification/gas turbine systems in 1998, and will produce over 15 megawatts of biomass power from wood resources.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Renewable Energy Commercialization--Geothermal Power (Climate Plan Action 26)

This initiative is part of DOE’s Geothermal Energy Research and Development Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$0.3 billion
- Energy savings of 0.15 quads
- Carbon-equivalent savings of 3.5 MMT

To increase the competitiveness of geothermal power and educate utility companies on the advantages of geothermal power, DOE led a collaboration of the geothermal industry, investor-owned and municipal utilities, and the federal government to develop the Geothermal Power Initiative. The initiative has accelerated commercial operation of cost-shared geothermal projects, including the development of a pipeline to deliver treated municipal wastewater to raise reservoir pressure and increase the volume of hydrothermal fluids at the Geysers field in California; and cost sharing of initial power plants (on the order of 10 megawatts) at new geothermal fields.

Geothermal power has important advantages over fossil-fired, electric-generation technologies, including negligible atmospheric emissions and fixed fuel costs. These programs are designed to bring additional geothermal electrical power generation on line within the next three years and to stimulate new power development into the next century.

Partners include (1) the geothermal industry, which has helped plan the collaborative effort and has responded to solicitations for cost-shared projects, and (2) utilities, which will provide the market for geothermal power purchases. Interagency collaborators include the U.S. Department of the Interior's U.S. Forest Service.

Achievements

- Using system designs and components developed by the DOE/industry technology-development partnership formed in the mid-1970s, the U.S. geothermal industry has deployed about 1,000 megawatts of new geothermal electric facilities at 12 sites in the western United States.
- A solicitation for cost-shared geothermal power projects was published in the Federal Register in March 1995.
- The Idaho Operations Office is reissuing a solicitation to identify a recipient who will conduct a small-scale commercial demonstration project during the fall of 1997.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Renewable Energy Commercialization--Geothermal Heat Pumps (Climate Plan Action 26)

This initiative is part of DOE's Geothermal Energy Research and Development Energy Research and Development Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$0.5 billion
- Energy savings of 0.31 quads
- Carbon-equivalent savings of 7.2 MMT

The goal of this action is to realize "400,000 by the year 2002" in annual geothermal heat pump (GHP) sales. With 120 utility partners representing a majority of the nation's electric customers, this collaborative effort is on track for reaching this goal.

GHPs are among the most efficient technologies for providing heating, cooling, and water heating to residential and commercial buildings. However, they will not likely emerge as a mainstream heating, ventilation, and air conditioning option without concerted efforts to increase cost-competitiveness, public knowledge of their availability and merits, and the GHP industry's ability to design, install, and maintain GHP systems.

To address these needs, the Geothermal Heat Pump Consortium--comprised of electric utilities, GHP manufacturers, trade groups, environmental organizations, EPA, and DOE--has launched a "Geothermal Heat Pump Technology Demonstration and Market Mobilization Program." The program is designed to reduce energy consumption, greenhouse gas emissions, and space-conditioning costs for residential and commercial building users by lowering costs associated with initial GHP installations. To build public confidence in the technology and to avoid the use of many different names, the industry has elected to use the name Geo Exchange to "brand" the technology.

Achievements

- In conjunction with the 1996 Olympics in Atlanta, GHPs were installed in a number of buildings.
- In 1996, 14 utilities committed over \$12 million in jointly funded GHP pilot and demonstration programs.
- In 1995 and 1996, over 4,000 Geo Exchange units were installed at Louisiana's Fort Polk Army Base. Statistically valid data show an annual savings of over 30 million kilowatt-hours and a summer-peak-demand reduction of 6.7 megawatts.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Renewable Energy Commercialization--Photovoltaics (Climate Plan Action 26)

This initiative is part of DOE's Photovoltaics Systems Research and Development Program. In the year 2010, this broader program will generate:

- Energy cost savings of \$0.06 billion
- Energy savings of 0.03 quads
- Carbon-equivalent savings of 0.6 MMT

DOE is working with the photovoltaic (PV) industry and others to reduce the price of electricity from PV systems, raise the lifetime of PV modules to 30 years, and increase PV module efficiencies. DOE's program efforts focus on three major elements: market conditioning, joint ventures, and strategic technological research.

This action is being accomplished via four major projects: TEAM-UP, a market-acceleration program taking place in cooperation with the Utility Photovoltaic Group (UPVG); Renewable Energy Technology Analysis, a program to evaluate and promote understanding of long-term costs and benefits of PV technologies; a program that supports state-level planning; and a program to support consumer advocates who will

evaluate the cost-effectiveness of PV installations. TEAM-UP will address both grid-connected applications of PV, as well as the grid-independent PV, applications.

Achievements

- DOE's most active partner, the Utility Photovoltaic Group (UPVG), has grown into an 84-member organization representing all sectors of the electric utility industry and more than 45 percent of U.S. kilowatt-hour electricity sales.
- The UPVG awarded eight contracts for market-development efforts for grid-independent PV applications, which collectively identified 130 utilities with potential to participate in market-development efforts.
- One grid-independent application team receiving UPVG support, the Photovoltaic Services Network, represents more than 40 electric utilities in 12 states in the West and Midwest.
- To date, the UPVG has awarded contracts to 19 teams, installing \$50 million in new PV installations with a 4:1 industry/DOE cost-shared ratio. The project includes more than 1,640 individual PV systems totaling more than 8 megawatts, all connected to electric utility systems. The awards will result in new PV installations in more than 25 states nationwide.
- DOE supported the installation of a 340-kW PV roof system, the world's largest PV roof system, in the 1996 Olympic Natatorium in Atlanta.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Renewable Energy Commercialization--Wind (Climate Plan Action 26)

This initiative is part of DOE's Wind Program. In the year 2010, this broader program is expected to generate:

- Energy cost savings of \$0.6 billion
- Energy savings of 0.26 quads
- Carbon-equivalent savings of 5.2 MMT

Interest in wind power technology is high, but the current lack of a well-established infrastructure for manufacturing, installing, and servicing wind turbines presents a great obstacle to commercialization. Representatives from interested parties in wind deployment--such as electric utilities, utility trade organizations, wind turbine equipment manufacturers, consumer groups, environmental groups, and state and federal regulators--joined with DOE to form a wind collaborative whose members selected the name National Wind Coordinating Committee (NCC). Its goal is to ensure the responsible

use of wind energy in the United States--an increasingly important goal, as wind energy provides the environmental benefit of zero-emission electricity generation.

DOE's principal support includes: expansion of the existing Turbine Verification Program, cost-shared deployment of wind energy to enhance infrastructure development, assessment of wind resources, and avian wind research. The Wind Turbine Verification Program provides co-funding support to a consortium that evaluates prototype wind turbines in commercial utility settings (6 megawatts or larger). The commercialization initiative shares the cost of developing full-fledged wind power plants (25 megawatts or more). The Utility Resource Assessment Program promotes wind energy by assisting utilities in evaluating possible sites for wind deployment. Finally, the Avian Research Program implements a broad-based scientific program to assess the impacts of wind development on avian populations.

Achievements

- In December 1994, DOE (through the National Renewable Energy Laboratory) issued a solicitation seeking cost-shared wind-farm projects. Eight proposals for more than 200 megawatts were received. In September, NREL announced its selection of three projects totaling 61 megawatts.
- To represent the interests of the nation's electric utilities and independent power producers in the NCC, the Utility Wind Interest Group was formally organized and incorporated.
- With the assistance of DOE cost-sharing, the Utility Wind Interest Group, Inc., selected six of nine possible proposals to collect and analyze wind data at multiple sites across the nation. Participating electric utilities are providing 65 percent of the funding. Two projects with 13-megawatt capacity are moving forward.
- DOE will provide technical assistance to construct wind turbine power plants in Minnesota and Iowa through NREL. Project planning advice and performance reports will be provided for the next five years.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Integrated Resource Planning (Climate Plan Action 27)

Utility companies, the state regulators who oversee them, and legislators need new analytical and management tools to make sound decisions in an increasingly complex and competitive utility environment. The Integrated Resource Planning (IRP) program addressed this need.

This initiative began in 1994 by supporting research on policy and planning tools that support both supply and demand issues. The program expanded to include an increasing emphasis on outreach and education to put IRP tools in the hands of state and regional regulators, legislators, and utility managers. The IRP program served state utility commissions, state energy offices, independent power producers, and utilities. Key partnerships included the National Association of Regulatory Utility Commissioners (NARUC), the National Conference of State Legislatures (NCSL), trade associations (including renewable-energy producer organizations), and energy-efficiency advocacy groups.

The IRP program consisted of the Education Voucher Program, which provides educational assistance for state regulators and their staff; the Electric Utility Restructuring Partnership, which provides information and analysis to states in formulating options for effective utility restructuring; DOE's IRP in Public Power Project, in conjunction with the American Public Power Association and the National Rural Electric Cooperative Association, which provides technical assistance to small public power utilities that wish to use IRP and demand-side management in their management operations; and support for state IRP initiatives through NARUC and NCSL.

Due to funding cuts, this program was terminated. The following achievements were realized before the program's termination.

Achievements

- Of the 335 applications for educational vouchers the program received during its operation, the program awarded more than 230 vouchers worth approximately \$250,000. The vouchers were used for a variety of purposes, including conducting renewable-energy workshops and obtaining technical resources, such as software and technical reports to enhance IRP-related decision making. In most cases, these resources would not have been accessible to state agencies without the IRP-DSM voucher program.
- In its first two years before its termination and during the budget appropriations process, the program sponsored more than 30 seminars to provide state regulators with a fundamental knowledge of IRP.
- IRP's national Performance-Based Rate-Making design workshop attracted more than 100 participants.
- The program provided funding for more than 100 national studies of IRP and IRP-related issues that have been delivered to all states.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Energy-Efficient Distribution Transformer Standards

(Climate Plan Action 29)

U.S. electric utilities use an estimated 40 million distribution transformers. Although utility distribution transformers collectively have a high rate of efficiency, they account for approximately 61 billion kilowatt-hours (kWh) of the 229 billion kWh of energy lost annually in the delivery of electricity. The Energy Policy Act of 1992 required DOE to determine if distribution transformer standards are warranted. This initiative was established to evaluate the feasibility of efficiency standards for electric distribution transformers, targeting single-phase distribution transformers up to 833 kilovolt ampere (kVa) and three-phase transformers up to 2,500 kVa.

To conduct this evaluation, DOE established partnerships with electric utility associations, distribution transformer manufacturers associations, and commercial and industrial facility owners/operators. DOE will assess whether distribution and efficiency standards are technologically feasible, economically justified, and result in significant energy savings. If the findings support formal development of efficiency standards, DOE will promulgate rulemakings for testing, standards, and labeling requirements.

Achievements

- In February 1995, DOE submitted a report to Congress on The Feasibility of Replacing or Upgrading Utility Distribution Transformers During Routine Maintenance.
- In July 1996, DOE published Determination Analysis of Energy Conservation Standards for Distribution Transformers.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

ENERGY STAR[®] Transformer Program (Climate Plan Action 30)

In the year 2010, the ENERGY STAR Transformers program is expected to generate:

- Energy cost savings of \$0.8 billion
- Energy savings of 0.1 quads
- Carbon-equivalent savings of 1.4 MMT

Approximately 40 million distribution transformers are in service on utility transmission lines. These transformers, which convert power from high voltages used in the transmission of electricity to lower voltages used in homes and businesses, lose approximately 61 billion kilowatt-hours of energy annually.

The ENERGY STAR[®] Transformer Program seeks to reduce these losses by encouraging utilities to overcome barriers to purchasing cost-effective and energy-efficient

transformers and by encouraging manufacturers to produce high-efficiency transformers using available technologies. In addition, EPA is working with industry members to develop technical tools to analyze highly complex transformer use and sizing decisions. Finally, EPA will encourage utilities and regulatory commissions to reduce any regulatory barriers that prevent the implementation of cost-effective, supply-side efficiency investments, such as efficient transformers.

The ENERGY STAR Transformer Program was launched successfully in April 1995, with over 85 percent of transformer manufacturers already participating. The program is on target to achieve its CCAP goal for saving over 2 billion kilowatt-hours of electricity in the year 2000. The program has developed new marketing strategies that demonstrate the benefits of high-efficiency transformers in a competitive electric industry. In addition, the program has released several technical tools and reports that are focusing attention on distribution efficiency and assisting with efficient transformer selection.

Achievements

- The program currently has 41 Utility Partners who purchase approximately 10 percent of the distribution transformers sold annually to utilities.
- The program currently has 9 Manufacturing Partners representing more than 85 percent of the distribution transformer manufacturing market.

Contact: Pete South, EPA, Atmospheric Pollution Prevention Division, 202-233-9482.

Green Power Network (New Climate Plan Action)

DOE has developed an Internet-based information network known as the Green Power Network. Accessible through DOE's Office of Energy Efficiency and Renewable Energy home page, the network provides and exchanges information on successful green power programs and provides network links to utilities, power marketers, public entities, and consumer and environmental organizations that have already developed or are interested in developing green power programs. The provision of this information and the information links will help encourage electricity suppliers and customers to form green power supply and buyer groups.

The electric power industry is undergoing unprecedented change, with the regulated monopoly structure of the industry becoming increasingly subject to competition. Wholesale competition has resulted in a price-dominated market in which renewables, which generally have high front-end cost structures, are being disadvantaged.

At the same time, retail competition should lead to a greater number of service options for electricity customers, some of which will include renewable energy. Since utility customers and public opinion surveys have identified strong public support for the development of clean energy sources, the ability of customers to express a market

preference for renewable-energy sources can be a key driving force in moving greater amounts of renewables into the market. Already, several utilities have developed customer-oriented “green pricing” programs, and a handful of municipalities have taken action to acquire renewables-based power to serve their loads.

These “green marketing” approaches employ market-based mechanisms to promote greater adoption of renewables and are entirely compatible with ongoing attempts to introduce greater competition into the generation and delivery of electricity. However, only a handful of power providers and customers have attempted to tap into this market. There is a need to more broadly disseminate information and experiences with green power programs, so that other organizations and market entities can apply this information to design and implement successful green power programs.

The Green Power Network is a site dedicated to providing information and points of contacts on green power programs and activities. DOE has worked with electricity-sector organizations in the development of the web site, and is linking to other green power-oriented businesses and organizations. This web site can be accessed at <http://www.eren.doe.gov/greenpower>. To qualify for a link to the web site, businesses and organizations should have an existing green power program underway.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Natural Gas STAR (Climate Plan Action 32)

The Action Plan expanded the Natural Gas STAR program. In the year 2010, the full program is expected to generate:

- Methane savings of 55 billion cubic feet
- Energy cost savings of \$100 million
- Carbon-equivalent savings of 6.0 MMT

Through the Natural Gas STAR program, EPA encourages natural gas companies to adopt cost-effective technologies and practices that reduce emissions of methane, a potent greenhouse gas. In March 1995, the program was expanded from the transmission and distribution sectors to include the production sector. In addition to providing implementation support, EPA provides partners with public recognition and works to remove unjustified regulatory barriers. Companies submit an implementation plan to EPA after becoming a partner and implement the plan over the next three years.

By working with the natural gas industry, Natural Gas STAR has identified nine cost-effective, methane-reducing best management practices (BMPs). EPA has developed a series of tools to help partners implement these BMPs, including an implementation

guide measurement program and a series of “lessons learned” studies that communicate superior implementation of BMPs by program partners.

Achievements

- In 1996, the Natural Gas STAR program reduced methane leakage from natural gas pipelines by over one million metric tons of carbon-equivalent emissions.
- The expanded program includes 65 corporate partners representing:
 - 65 percent of transmission company pipeline miles,
 - 32 percent of distribution company pipeline miles, and
 - 33 percent of U.S. natural gas production.
- The American Gas Association, the American Petroleum Institute, the Interstate Natural Gas Association, the International Centre for Gas Technology Information, the National Association of Regulatory Utility Commissioners, the Natural Gas Supply Association, and the Southern Gas Association have endorsed the Natural Gas STAR program.
- In addition, the Gas Research Institute endorsed the program in April 1994, pledging \$4 million of its annual budget to projects that reduce methane emissions.

Contact: Rhone Resch, EPA, Atmospheric Pollution Prevention Division, 202-233-9793.

Landfill Rule and Landfill Methane Outreach Program (Climate Plan Actions 33 and 34)

In the year 2010, the Landfill Methane Outreach Program is expected to generate:

- Methane savings of 26 billion cubic feet
- Energy cost savings of \$50 million
- Carbon-equivalent savings of 2.9 MMT

Landfills are the largest source of U.S. anthropogenic methane emissions. Because methane is a fuel, landfills also represent a tremendous energy resource. Through the Landfill Methane Outreach Program (LMOP), launched in December 1994, EPA is encouraging landfills across the nation to capture and use their landfill gas emissions. This voluntary effort works hand-in-hand with EPA’s landfill New Source Performance Standards and Emissions Guidelines (also known as the “Landfill Rule”) to promote cost-effective reductions in methane emissions. Promulgated in March 1996, the Landfill Rule requires large landfills to capture and combust their landfill gas emissions. By providing potential project partners reliable technical and economic information on the opportunities to use landfill gas as a fuel, creating innovative financing opportunities, and demonstrating

the many benefits of converting landfill gas to energy, the LMOP is helping landfills affected by the Landfill Rule to achieve the maximum benefit at the lowest cost.

EPA works with state energy and environmental agencies, landfill owners, utilities, trade associations, and industry to lower the barriers to landfill gas-to-energy project development. The LMOP disseminates reliable information, identifies project opportunities, and creates momentum for increasing the economically and environmentally beneficial use of landfill gas.

Together the LMOP and the Landfill Rule are expected to achieve reductions of over 35 MMTCE in the year 2000.

Achievements

- Allies include 18 state agencies in 13 states, 15 utilities, and more than 70 industry representatives, including project developers, equipment suppliers, financiers, and landfill gas end users.
- 6 State Ally workshops have been held, and several more are scheduled.
- A wide range of focused products have been developed and distributed, including:
 - a project development handbook;
 - profiles of landfills that are good candidates for energy recovery in 20 states;
 - primers outlining key state regulatory and incentive information for 3 states;
 - software to evaluate the most attractive project options for specific landfills, including estimation of costs and benefits; and
 - fact sheets and issue papers providing guidance on critical issues.
- Provided Landfill Rule guidance and workshops for state agencies and affected landfills.
- Catalyzed development of at least 24 new landfill gas-to-energy projects.

Contact: Tom Kerr, EPA, Atmospheric Pollution Prevention Division, 202-233-9768.

Coalbed Methane Outreach Program (Climate Plan Action 35)

In the year 2010, the Coalbed Methane Outreach Program is anticipated to generate:

- Methane savings of 29 billion cubic feet

- Energy cost savings of \$55 million
- Carbon-equivalent savings of 3.2 MMT

In 1990, methane emissions associated with coal mining operations accounted for approximately 18 percent of human-related U.S. methane emissions. Launched in spring 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 13 U.S. mines are recovering and using methane. Under this program and as a result of the Energy Policy Act of 1992, an additional 47.8 trillion Btus of methane energy are expected to be recovered annually, representing approximately 25 new or expanded projects by 2000.

Coal mine methane projects must meet site-specific technical and market conditions to be profitable. Many general market barriers and opportunities can either hinder or encourage projects. The program works on a mine-by-mine basis to identify and overcome the specific technical, legal, market, and financial barriers to project implementation. Program staff works directly with the coal mine staff to prepare technical, financial, and market analyses that identify profitable project opportunities. The program also works with developers, state and local governments, and potential gas markets to identify and overcome the various generalized technical, market, financial, and legal barriers.

Achievements

- During 1995 and 1996, at least seven 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. In 1996, a contract was signed to upgrade lower-quality mine gas from two active mines and two abandoned mines for pipeline injection--the first project of its kind.
- EPA worked with operators of several mines to develop detailed technology and financial assessments of the profitable opportunities for coal mine methane projects. These assessments are catalyzing project developments.
- EPA developed guides for state, local, and federal assistance programs that pinpoint sources of loans, grants, and technical assistance for profitable coal mine methane projects. In addition, EPA prepared a comprehensive guide for private-sector financing of coal mine methane projects.
- EPA evaluated and reported on technological options for enhanced coalbed methane recovery, use, and markets that have lowered the informational barriers to profit-making coalbed methane projects.

- In 1996 and 1997 EPA hosted two national conferences that focused on key financial and policy issues related to coalbed methane project development.

Contact: Karl Schultz, EPA, Atmospheric Pollution Prevention Division, 202-233-9468.

Methane Recovery Systems--Coal Mining (Climate Plan Action 36)

DOE's Office of Fossil Energy and EPA (Climate Plan Action 35) have jointly supported outreach, cost-shared demonstrations, and market-entry projects to investigate and apply technologies for capturing and using methane emitted during coal mining. Methane is highly explosive and, when emitted into the mine workings during coal mining operations, can be a serious safety hazard. Within DOE the Office of Fossil Energy is primarily responsible for the methane recovery program. Management of the program is coordinated with EPA; the National Mining Association; fuel cell, gas turbine, and internal combustion engine manufacturers; private industry; utilities; and others.

The program has supported partnership teams, led by the coal industry, that are developing the application of evolving and existing technologies for recovery and use of coal mine methane gas. The program has three operational phases: Phase I--feasibility study of the proposed program and solicitation of cost-shared demonstrations, Phase II--detailed design of the proposed demonstrations, and Phase III--implementation of pilot demonstrations.

The program involves partners in planning, implementation, and financing. Coal mining and natural gas production industries are included as potential partners for gas recovery and sales. Natural gas transmission, electrical power, and coal mining companies are the potential users of the recovered gas. Power-generation equipment vendors may join in partnerships to provide the hardware for recovery and use. Local communities may also be partners for providing local fuel or power in the community or for industrial/energy parks.

Achievements

- Five Phase II coal mine methane projects with multiple partners are currently completing detailed designs for field recovery and use demonstration efforts in 1998. Project partners include a coal operator, a utility, an engineering firm, and an engine manufacturer.
- Two of the project efforts have partly completed the design of the field demonstrations and are beginning to recover initial quantities of coal mine methane.
 - One of these projects involves DOE, Northwest Fuel Development, an active coal mine and an electric utility in Harrison County, Ohio. The present installed capacity of this facility is 500 kilowatts, or about one-quarter of the coal mine's

total power consumption. The existing generators are driven by automobile-derivative internal combustion (IC) engines. Design work is currently underway in cooperation with Energy Research Corporation to develop a demonstration unit with a capacity of 300 kilowatts. It is anticipated that the use of the fuel cell will allow for more flexible operation of the IC engines.

- The second project intends to use methane contained in the mine ventilation exhaust and gas from gob wells drilled into the strata just above the longwall mining face. The total methane emissions from the Emerald mine (Greene Co., Pa.) are capable of generating 50 or more megawatts. The specific hardware for the prototype is being determined, and a test plan is being developed for operation.

Contact: DOE, Office of Fossil Energy, 202-586-4756; or DOE Federal Energy Technology Center, 304-285-4547.

Methane Recovery Systems--Landfills (Climate Plan Action 37)

Municipal landfills are the single largest source of methane emissions nationwide, generating over one-third of the nation's methane greenhouse gas. DOE, through its methane capture research, development, and demonstration activities, and EPA, through its public outreach (Climate Plan Action 34), have worked jointly to maximize methane gas use and recovery from landfills.

The Solid Waste Management Association of North America (SWANA) has been a key partner with DOE in the design and delivery of this initiative. SWANA is the largest professional organization representing landfill gas recovery. The group has been conducting meetings and symposia on landfill gas recovery since the late 1970s.

Due to funding cuts, DOE's participation in this program was terminated. The following achievements were realized before the program's termination.

Achievements

- A workshop was held to identify technical barriers to the recovery and use of landfill-generated methane gas, resulting in an information base for planned activities.
- Two projects--the study and verification of landfill gas prediction models and the development of "manuals of practice" for gas recovery--were initiated as a result of the workshop.
- A Notice of Intent was published in 1994 in the Commerce Business Daily to determine the level of interest of industry and stakeholders in cost-shared projects for landfill gas recovery and use. Thirty-one responses were received, indicating strong support from private-sector landfill operators.

An increased knowledge base will result from the two study initiatives and from the relationships that have been established with the professional community through collaboration with SWANA. The verified model for the prediction of methane gas levels at landfill sites will provide better information to landfill operators trying to estimate the amount of gas they can expect to recover over time.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

AgSTAR Program (Climate Plan Action 38)

In the year 2010, the AgSTAR program is expected to generate:

- Methane savings of 16 billion cubic feet
- Energy cost savings of \$30 million
- Carbon-equivalent savings of 1.8 MMT

Launched at the White House Conference on Climate Change in the spring of 1994, this cooperative effort of EPA, USDA, and DOE is a voluntary pollution-prevention program with the livestock industry. EPA and USDA work 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, managing odors, and reducing fertilizer costs.

To join AgSTAR, livestock producers sign a memorandum of understanding and agree to survey their facilities to determine if a methane-recovery system would be profitable for their farm(s). If it is projected to be profitable, the producer agrees to install a methane-recovery system within three years.

To date, project installations have been slower than expected, due to delays in initiating model farms and utility industry restructuring. Installations are increasing, however, due to industry emphasis on odor control and other factors.

Achievements

- AgSTAR has more than 40 partners, representing more than 400 farms. The program also has 50 Allies, representing system and equipment manufacturers, educational institutions, state and local governments, and others.
- EPA has issued the AgSTAR Handbook, a comprehensive methane-recovery handbook and reference guide organized for specific livestock-rearing methods and manure management strategies.

- EPA has released FarmWare version 1.0, the AgSTAR decision-support software, which allows U.S. dairy and pork producers to conduct comparative technical and economic assessments of their facilities.
- EPA has initiated projects at model farm sites in key methane areas across the country. These model farms are demonstrating the successes of today's methane-recovery technology and the potential to recover methane at a profit. These farms also serve as educational facilities for Partners, Allies, and others interested in considering methane-recovery systems.
- USDA and EPA have jointly developed three interim standards related to biogas generation, capture, and utilization--Covered Anaerobic Lagoon, Plug Flow Digester, and Complete Mix Digester--which allow AgSTAR partners to participate in cost-share programs, such as EQP.
- USDA and EPA have jointly funded an engineering position, located in Raleigh, North Carolina, to serve as a regional specialist in environmental engineering and biogas recovery.

Contacts: Kurt Roos, EPA, Atmospheric Pollution Prevention Division, 202-233-9041; Barry Kintzer, USDA-NRCS, Conservation Engineering Division, 202-720-4485.

Ruminant Livestock Efficiency Program (Climate Plan Action 39)

In the year 2010, the Ruminant Livestock Efficiency Program is expected to generate:

- Methane reductions of 20 billion cubic feet
- Carbon-equivalent savings of 2.2 MMT

This collaborative effort between USDA and EPA aims to reduce 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 inefficiency of animal production.

This program encourages livestock producers to improve 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, improving 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.

Because fat production is energy-intensive, producing lower-fat products requires less feed per unit of product and results in less methane production.

Achievements

- In Utah and Washington State, regional projects were launched to study how improved livestock management practices reduce methane emissions from cattle. The information gathered by the collaborating universities is being transferred to livestock producers through local extension services.
- The Ruminant Livestock Efficiency Program has enabled USDA's National Resource and Conservation Service (NRCS) to expand upon its education and technical assistance activities in 10 states helping livestock producers improve grazing management and livestock production. Efforts include workshops, field tours, video programs, and distribution of published material.
- In collaboration with universities in Tennessee, Georgia, and Louisiana, a regional project has been launched for the southeastern United States, which focuses on improving efficiency of production on cow/calf operations. Plans were developed to study improved practices, mainly in the areas of grazing and forage management, and the effect they have on methane emissions and productivity. NRCS will use the information in technology-transfer programs. As part of this effort, "model farms" are being established in 10 states and Puerto Rico to demonstrate to producers that improved practices can be profitable and good for the environment.

Contacts: Mark Orlic, EPA, Atmospheric Pollution Prevention Division, 202-233-9043; Steve Carmichael, USDA-NRCS/EPA Liaison, 404-562-9374.

Significant New Alternatives Program (Climate Plan Action 40)

In the year 2010, Action 40 is expected to generate:

- Carbon-equivalent savings of 23.1 MMT

Perfluorocompounds (PFCs) and hydrofluorocarbons (HFCs) are among the most potent greenhouse gases. In addition to being characterized by high global warming potentials (GWPs), most PFCs and HFCs have extremely long atmospheric lifetimes, which means even small emissions will contribute to the cumulative atmospheric burden and will persist for up to thousands of years.

Emissions of PFCs and HFCs in this initiative fall into two categories: release from use as alternatives for ozone-depleting substances, and discharge from industrial processes. This action intends to reduce emissions of high-GWP gases by a regulatory pathway to restrict the use and emission of chemicals under the Significant New Alternative Policy (SNAP), authorized under Section 612 of the Clean Air Act.

Section 612 permits the control of uses for high-GWP gases if other alternatives to ozone-depleting substances exist and pose less risk to human health and the environment. Regulatory actions are also developed as part of the SNAP, and environmental stewardship activities have been designed to control industrial releases.

Achievements

- SNAP has promulgated four rules listing acceptable and unacceptable substitutes for ozone-depleting substances. Through these rules, EPA has restricted the use of substances by listing chemicals subject to Narrowed Use Limits. SNAP also has banned the use of some substances because of their high GWP properties (e.g., SF₆ is an unacceptable substitute for aerosol propellants due to its very high GWP and the existence of other compressed gases that perform equally well).

Contact: Reynaldo Forte, EPA, Stratospheric Protection Division, 202-233-9134.

Expansion to CCAP Action 40: Environmental Stewardship Initiative (New Climate Plan Action)

In the year 2010, this initiative is anticipated to generate:

- Carbon-equivalent savings of 10.0 MMT

This action expands ongoing work begun as part of the environmental stewardship activities under Action 40 of the Climate Change Action Plan. Environmental stewardship activities have been designed to control industrial emissions of perfluorocarbons (PFCs) and hydrofluorocarbons (HFCs). Among the most potent greenhouse gases, most PFCs and HFCs are characterized by high global warming potentials (GWPs) and extremely long atmospheric lifetimes. A high GWP implies that discrete emission of the gas can be up to several thousand times more potent than an equivalent quantity of carbon dioxide. Further, long atmospheric lifetimes for the gases mean that even small emissions will contribute to the cumulative atmospheric burden and persist for up to thousands of years.

PFCs and HFCs are intentionally used in the following three industries: (1) semiconductor production (SF₆, CF₄, C₂F₆, C₃F₈, NF₃, and CHF₃); (2) electrical power systems (SF₆); and (3) magnesium casting (SF₆). Use and emissions of PFCs by the semiconductor industry is expected to increase by 2000 due to growing use in production and demand for the microchip. The most potent greenhouse gas is SF₆, with a GWP of 23,900 and an atmospheric lifetime of 3,200 years. It is used by all three industries. Atmospheric concentrations of SF₆ are increasing at an estimated annual rate of 7-8 percent. Production rates for some of the PFCs are expected to grow.

Most emission reductions for these industries are believed to be possible through environmentally protective and cost-effective means. In all cases, the principles of pollution prevention are under consideration for reducing emissions. EPA has initiated a

cooperative reduction effort with the semiconductor industry and has begun discussions with the electrical and magnesium industries.

The semiconductor industry, through efforts of the Semiconductor Industry Association and its member companies, has worked with EPA to develop an agreement to endeavor to reduce emissions of PFCs. Eighteen individual companies have signed the memorandum of understanding with EPA, which has already received preliminary reports of successful attempts to reduce emissions. In the meantime, the electrical and magnesium industries have both expressed a desire to discuss voluntary reduction programs with EPA.

Contact: Elizabeth Dutrow, EPA, Atmospheric Pollution Prevention Division, 202-233-9061.

Partnership With HCFC-22 Manufacturers to Eliminate HFC-23 Emissions (Climate Plan Action 41)

In the year 2010, this initiative is expected to generate:

- Carbon-equivalent savings of 5.0 MMT

Chemical production of HCFC-22 results in the creation of HFC-23 (trifluoromethane) as a by-product. Vented to the atmosphere for the most part, HFC-23 is a very potent greenhouse gas, with a global warming potential of 11,700 and an atmospheric lifetime of 250 years.

This action is a voluntary environmental stewardship program designed to reduce releases of HFC-23. The U.S. producers of HCFC-22 have committed to EPA to reduce emissions of HFC-23 in the year 2000 by 5 MMTCE. Reduction opportunities will vary from company to company, but will most likely include process optimization, conversion to benign chemistries, and destruction.

Achievements

- HCFC-22 producers have completed an assessment of their 1990 HFC-23 emissions, and are continuing to report annual emissions.
- HCFC-22 producers are currently determining and implementing the most cost-effective practices for reducing HFC-23 emissions.
- In 1997, EPA and the producers coordinated to develop a set of performance-based emission measurement standards. The standards establish acceptable limits for air emissions data.

Contact: Elizabeth Dutrow, EPA, Atmospheric Pollution Prevention Division, 202-233-9061.

Aluminum Producer Partnership (Climate Plan Action 42)

In the year 2010, the Voluntary Aluminum Industrial Partnership is expected to generate:

- Carbon-equivalent savings of 2.4 MMT

Carbon tetrafluoride (CF₄) and carbon hexafluoride (C₂F₆) are emitted as by-products of the primary aluminum production process. Both of these perfluorocarbons (PFCs) are potent greenhouse gases with global warming potentials of approximately 6,500 and 9,200 times that of CO₂, respectively, and lifetimes that exceed 10,000 years. Through the Voluntary Aluminum Industrial Partnership (VAIP), EPA is partnering with primary aluminum producers to reduce PFCs emissions where technically feasible and cost-effective.

PFCs are generated during anode effects, which are temporary electrochemical disruptions in the production process. When they occur, energy that would otherwise be used to make aluminum is wasted. Under VAIP, partners work toward minimizing the number and duration of anode effects without sacrificing competitiveness. Many companies have already reduced their PFC emissions substantially through relatively minor technological and operational changes, such as the use of computer monitoring, changes in raw materials feeding techniques, and employee training. EPA estimates that such changes can help to reduce PFC emissions by 30-60 percent industry-wide.

Achievements

- As of December 1995, 12 companies representing 94 percent of the U.S. primary aluminum production capacity had joined VAIP.
- VAIP has developed CF₄ and C₂F₆ gas standards (through the National Institute of Standards and Technology) and has improved the fundamental understanding of these emissions (through research conducted at the Massachusetts Institute of Technology).
- EPA has conducted measurements of CF₄ and C₂F₆ at seven smelters in conjunction with primary aluminum companies.
- In 1996, EPA co-hosted an international conference on PFC emissions from aluminum smelting attended by representatives of more than 10 countries.

Contact: Eric Dolin, EPA, Atmospheric Pollution Prevention Division, 202-233-9044.

Accelerate Tree Planting in Nonindustrial Private Forests (Climate Plan Action 44)

In the year 2010, trees planted through this program are expected to sequester:

- 2.2 MMT of carbon

Through the Forest Stewardship Incentive Program, USDA's Forest Service and State Forestry agencies are providing technical assistance and up to 75 percent federal cost-sharing for the planting of additional trees on nonindustrial private lands. This program increases the uptake of carbon dioxide and storage of carbon in trees, forest soils, forest litter, and in understory plants. The goal of the program is to increase tree planting in the United States by 233,000 acres a year (10 percent) within five years and to maintain this expanded level of planting for an additional five years.

Achievements

- The USDA Forest Service has planted 135,000 acres of trees through fiscal year 1996 under the Stewardship Incentive Program.

Contact: Robert J. Moulton, USDA Forest Service, 919-549-4032.

Climate Challenge

The Climate Challenge program is a joint, voluntary effort of DOE and the electric utility industry to reduce, avoid, or sequester greenhouse gases. Utilities identify and implement cost-effective activities that are specified in agreements between DOE and individual electric utilities. Each utility reports its results annually, consistent with the guidelines for voluntary reporting of greenhouse gas emissions developed under Section 1605(b) of the Energy Policy Act of 1992.

Actions that utilities have committed to in their agreements include: efficiency improvements in end use, distribution, transmission, and generation; increased use of energy-efficient electrotechnologies; fuel switching to lower-carbon fuels and renewables; transportation actions; forestry actions; recovery of methane from landfills and coal seams; and the use of fly ash as a Portland cement substitute. A significant effect of the Climate Challenge program is the shift in thinking of electric utility management and strategic planners to include the mitigation of greenhouse gas emissions into their corporate culture and philosophy.

Achievements

- The utility industry developed nine Climate Challenge initiatives, including: the EnviroTech Charter, with over \$50 million committed to accelerate commercialization of renewable-energy technology and energy-efficient electrotechnologies; the Earth Comfort Program, to increase annual sales of energy-efficient geothermal heat pumps from 40,000 to 400,000; the Utility Forest Carbon Management Program, with over \$2 million committed to funding several domestic and international projects; through the nonprofit UtiliTre Carbon Company the International Utility Efficiency Partnerships, which is currently evaluating projects in 18 countries; and the Combined Purchasing Initiative, to aggregate utility purchasing power to create a market for

technologies, such as high-efficiency transformers and photovoltaics. Other initiatives include: EV America (electric vehicles), Electric End Use Efficiency Technology Initiative, Tree Power, and International Donated Equipment Initiative.

- Niagara Mohawk Power Corporation exchanged 1.75 million tons of CO₂ reductions for Arizona Public Service Company's 25,000 tons of sulfur dioxide allowances. Niagara Mohawk donated the allowances to a nonprofit environmental group to be retired.
- As of April 1997, 119 Participation Agreements were signed. The agreements represent 638 of the over 800 utilities that have expressed interest in the program, and 69 percent of 1990 electric generation and utility carbon emissions. These utilities' commitments are expected to reduce carbon emissions by over 44 MMTCE in the year 2000.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Climate Wise

Turning Industrial Energy Efficiency and Environmental Performance into a Corporate Asset

In the year 2010, Climate Wise is expected to generate:

- Energy cost savings of \$0.78 billion.
- Energy savings of 0.33 quads.
- Carbon-equivalent savings of 3.7 MMT.

Climate Wise is helping companies realize significant environmental and economic benefits through cost-effective industrial energy-efficiency and pollution-prevention actions. The program provides technical assistance and public recognition that result in the development and implementation of comprehensive emission-reduction action plans that achieve real results. Climate Wise's common-sense approach to pollution prevention allows companies tailor their action plans to meet the needs and opportunities of their operations.

Boiler efficiency, steam system optimization and maintenance, fuel switching and cogeneration, industrial process improvements, and air compressor system efficiency are just a few of the unique industrial actions Climate Wise companies are taking. Climate Wise partners are also encouraged to participate in other Climate Change Action Plan programs, such as DOE's Motor Challenge and EPA's Green Lights[®] programs, to ensure their plans are comprehensive.

The industrial sector accounts for about 30 percent of U.S. energy consumption and represents a broad array of emission-reduction opportunities. Climate Wise targets

this important sector, requiring each Climate Wise company to develop a comprehensive action plan within six months of joining the program and report the results of its actions annually through the Section 1605(b) Voluntary Reporting System.

Achievements

- In 1996, after the program's first full year of recruitment efforts, the number of Climate Wise companies grew by more than 700 percent. Partners now number more than 250 and represent more than 7 percent of U.S. industrial energy use.
- Climate Wise partners have already committed to undertake nearly 350 pollution-prevention and energy-saving actions. In 1996, companies documented savings of more than \$30 million annually. Many of the partners who joined the program in 1996 will be submitting their action plans in 1997. By the year 2000, the program expects to foster emission reductions of more than 3 million metric tons of carbon and fuel cost savings of nearly \$675 million.
- The State and Local Government Allies program collectively recruited more than 100 partners in 1996. This initiative, involving ten states and six local governments in 1996, has brought the federal, state, and local governments together to deliver better services to participating companies. In addition to the tremendous outreach capability, State and Local Government Allies are creating innovative services, such as regulatory incentives and low-interest loans, to help companies achieve meaningful results.

Contacts: Amy Manheim, DOE, Office of Industrial Technologies, 202-586-1507; Pam Herman Milmo, EPA, Office of Policy Planning and Evaluation, 202-260-4407; Climate Wise Line, 1-800-459-WISE or (703) 934-3830.

State and Local Climate Change Outreach Program

The Climate Change Outreach Program builds capacity to successfully reduce greenhouse gases at the state and local levels by providing needed information, tools, and infrastructure to state and local authorities. The program can be compared to a venture capital group that seeks out good investments. It helps decision makers identify and understand the impacts of climate change (e.g., public health, air quality, water resources) as well as assess and implement policies that result in the mitigation of the risks associated with climate change. Partners have a product--an action plan--that clearly shows the potential for greenhouse gas savings. Collectively, the program allows EPA to examine the opportunities for partners and extrapolate potential nationwide savings. In addition, the program has emphasized the development and analysis of innovative and integrated actions that solve multiple environmental and economic problems.

- Recent changes in the program focus on outreach and communication activities to:
- Motivate officials to take action.
- Identify opportunities to contribute to the international process led by the federal government.

- Analyze the economic and environmental impacts of domestic greenhouse gas policy at the regional, state, and local levels.

Achievements

- Thirty states have completed or nearly completed state greenhouse gas inventories, enabling them to identify where their emissions are growing fastest.
- Nine states have completed and 11 others have nearly completed action plans, which have enabled them to identify numerous cost-effective measures to reduce greenhouse gas emissions.
- Thirteen partners have completed demonstration greenhouse gas reduction projects or impact studies.
- State partners from Oregon and Utah are lending technical expertise to the U.S. Country Studies SNAP Program as Project Officers and Technical Experts.
- Forty-one U.S. cities are participating in the Cities for Climate Protection Campaign. Five participating cities have committed to a 20 percent emissions target and timetable, and the remaining cities are preparing local action plans. Over half of the cities are starting to implement programs that reduce greenhouse gas emissions.
- The Environmental Council of the States is engaging state environmental commissioners on climate change issues through education about the impacts of climate change on their states and the effect of changes in domestic policy that may result from the international climate negotiations.
- State- and local-targeted information is being disseminated to partners through electronic mailings, EPA's web site on global warming, workshops, and publications.

Contact: EPA, Office of Economy and Environment, 202-260-4314.

U.S. Country Studies Program

A joint initiative of 10 U.S. government agencies, the U.S. Country Studies Program is assisting 55 developing countries and countries with economies in transition with climate change studies designed to build human and institutional capacity to address climate change. The program is also assisting 18 of these countries in using their study results to prepare national climate change action plans that will lay the foundation for their national communications required under the U.N. Framework Convention on Climate Change (UNFCCC).

The primary objectives of the U.S. CSP are:

- To enhance the abilities of countries and regions to inventory their greenhouse gas emissions, assess their vulnerabilities to climate change, and evaluate strategies for mitigating emissions and adapting to the potential impacts of climate change.
- To enable countries to establish a process for developing and implementing policies and measures to mitigate and adapt to climate change, and for reexamining these policies and measures periodically.
- To develop information that can be used to further regional, national, and international discussions of climate change issues and increase support for the FCCC.

Achievements

- Initiated a two rounds of support for national action plans to 18 countries (Bangladesh, Bolivia, Bulgaria, China, Czech Republic, Egypt, Hungary, Indonesia, Kazakstan, Mexico, Micronesia, Philippines, Russian Federation, Tanzania, Thailand, Ukraine, Uruguay, and Venezuela).
- Published several handbooks on methodologies, and three synthesis reports (emission inventories, vulnerability and adaptation assessments, and country strategies) to document the results of the studies.
- Sponsored or co-sponsored more than 30 technical workshops to share methods, results, and country strategies.
- Published handbooks and held training workshops on preparation of plans and technology assessments, and trained over 2,000 analysts in 70 countries.
- Sponsored more than 200 publications or data bases by the 55 countries.
- Developed handbooks and synthesis reports that have made important contributions to the work of the Global Environment Facility, the Intergovernmental Panel on Climate Change, and the Subsidiary Bodies to the Climate Convention, as well as other international organizations.
- Helped 55 countries complete preliminary emission inventories, vulnerability and adaptation assessments, and mitigation assessments.
- Continues to complement programs implemented by other donors (e.g., the United Nations Development Program, the United Nations Environment Program, the Global Environment Facility, and individual member countries of the Organization for Economic Cooperation and Development).

Contact: Director, U.S. Country Studies Program, PO-6, 1000 Independence Ave., S.W., Washington, D.C. 20585, 202-586-3288; Internet site at <http://www.gcrio.org/csp/webpage.html>.

Expand Markets for Next-Generation Lighting Products (New Climate Plan Action)

In the year 2010, this initiative is expected to generate:

- Energy cost savings of \$0.4 billion
- Energy savings of 0.1 quads
- Carbon-equivalent savings of 0.7 MMT

This action is expected to expand markets for energy-efficient lighting products through coordinated federal programs primarily targeting residential lighting. The action is based on a comprehensive strategy to convert incandescent lighting to energy-efficient alternatives by delivering a portfolio of products to meet a range of needs over an extended time horizon. The objectives are to promote:

- use and improvement of compact fluorescent products (CFLs),
- conversion of high-energy-using fixtures to dedicated CFL fixtures, and
- filling-in a key product gap with a low-cost, drop-in replacement for standard incandescent light bulbs.

A first step already taken under this action at the federal level is a procurement effort jointly led by Office of the Secretary of Defense and DoD's Defense Supply Center-Richmond, implemented with the joint support of the DOE and EPA. DoD is seeking to purchase low-cost, drop-in replacement products for standard-sized light bulbs that provide at least a 30 percent energy savings, compared to traditional incandescent lamps. DoD is serving as the "anchor buyer" in an effort that ultimately will involve state and local agencies and private-sector procurement offices. Once new products have been introduced to the market through this mass procurement, additional efforts will be implemented to further enhance their market penetration.

Contacts: Tracy Narel, EPA, Atmospheric Pollution Prevention Division, 202-233-9145; Bill Noel, DOE, 202-586-6149.

The U.S. Initiative on Joint Implementation

The U.S. Initiative on Joint Implementation (USIJI) is a pilot program encouraging U.S. organizations to implement projects internationally that reduce, avoid, or sequester greenhouse gases. Since its launch in 1993, USIJI has become the largest effort worldwide to explore options for countries to jointly reduce greenhouse gases. Its international outreach activities and workshops (attended by several hundred potential participants from approximately 50 countries) have positively influenced international understanding of joint implementation and its broad acceptance by Parties to the U.N Framework Convention on Climate Change. Other countries, including Canada and Japan, have announced pilot efforts similar to USIJI.

The goals of the USIJI program are to:

- Promote technology cooperation with and sustainable development in developing and transition countries.
- Test and evaluate methods to measure, track, and verify emission reduction costs and benefits.
- Encourage private-sector investment and innovation in developing and disseminating technologies to reduce or sequester greenhouse gas emissions.
- Establish an empirical base for the formulation of international criteria for joint implementation.

Achievements

- As of December, 1996, USIJI had received 61 proposals from 26 countries for projects that were designed to reduce, avoid, or sequester greenhouse gases, using a diverse set of technologies, including renewable, fuel-switching, energy-efficiency, methane-recovery, and sustainable land-use practices. Of these, the Evaluation Panel has approved 23 projects representing innovative technologies and practices in nine countries.
- The USIJI Secretariat streamlined the project review and acceptance procedures and has published draft guidelines for preparing USIJI proposals.
- The USIJI Secretariat prepared a very detailed report to the Secretariat of the UNFCCC, which set a high standard for Annex I and non-Annex I parties under the AIJ pilot phase.
- The USIJI Secretariat established a technical assistance program to provide assistance to project participants in the areas of obtaining financing, developing monitoring and verification plans, and screening new projects for compatibility with project criteria.

Contacts: Director, USIJI Secretariat, PO-6, 1000 Independence Ave., S.W., Washington, D.C. 20585, 202-586-3288; Information Line: 202-586-3467; Fax-on-Demand: 202-260-8677; Internet web site: <http://www.ji.org>

Fuel Cells Initiative (New Climate Plan Action)

This initiative is part of DOE's Space Conditioning Program. In the year 2010, this broader program is anticipated to generate:

- Energy cost savings of \$1.1 billion

- Energy savings of 0.13 quads
- Carbon-equivalent savings of 3.5 MMT

The Fuel Cells initiative offers a unique technology that can revolutionize the way building power, heating, cooling, and hot water are generated and maintained. No other cogeneration system can generate electricity, provide heat, and hot water with the low emission, low noise, and high efficiency of the fuel cell.

Fuel cells have a large potential to reduce carbon emissions in power generation and buildings. Among other energy sources, fuel cells can be powered by hydrogen. They produce both electrical and thermal energy through an electrochemical reaction, and they have exceptionally high efficiencies with water as the only by-product. The principal obstacle to widespread use of this technology is its high cost, although a very large potential exists for reducing those costs.

DOE's initial goal is to develop low-cost, 50-kilowatt fuel cell technologies that use reformed methane to produce hydrogen fuel to power commercial buildings. DOE will research methane steam reforming for the Proton Exchange Membrane (PEM) fuel cell; low-cost, high-performance membranes; CO-tolerant catalysts; and light-weight, high-conductivity electrodes (bi-polar plates).

DOE will also develop lower-cost materials and fuel reformers to produce the hydrogen fuel. Toward this end, DOE will work closely with researchers, fuel cell manufacturers, and the gas industry to develop and deploy low-cost PEM fuel cells to demonstrate their high efficiency, low noise, and low carbon production.

Within the next four years, DOE plans to complete: a methane reformer breadboard system, system-level tests, field testing, and a prototype for installation in buildings. Since fuel cells in buildings would differ considerably from those used in automobiles, the 50-kilowatt fuel cell will be developed in conjunction with DOE's advanced automotive technology program.

Achievements

Four contracts are in place that focus on: membrane research, natural gas reforming, catalyst development for CO tolerance, and bi-polar plate development.

Contact: Energy Efficiency and Renewable Energy Customer Service Center, 1-800-363-3732 (Domestic) or 703-287-8391 (International).

Appendix b:

IPCC reporting tables

This appendix contains a series of tables that summarize the emissions and activity data for the greenhouse gas sources discussed in the body of this report. These tables conform to

the guidelines established by the IPCC (IPCC/OECD/IEA/UNEP 1995; Vol. 1) for consistent international reporting of greenhouse gas emission inventories. In some instances the format has been changed from the format presented in this report in order to conform to the IPCC table guidelines. These reformatting differences do not affect total U.S. emission calculations.

[Editor's note: Tables not Available]

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