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Global Warming State Department Vol 1 [2]

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Table 4-12

Summary of AIJ Projects Reported Under Annex I

Place and Title of Activity	Type of Project
Belize	
Rio Bravo Carbon Sequestration Pilot Project	Forestry/Land Use—Forest management and conservation
BEL/MAYA Biomass Power Generation Project	Renewable Energy—Biomass
Bolivia	
Noel Kempff M. Climate Action Project	Forestry/Land Use—Forest management
Costa Rica	
Plantas Eólicas, S.A., Wind Facility	Renewable Energy—Wind; fuel switching
ECOLAND: Esquinas National Park	Forestry/Land Use—Forest management and conservation
KLINKIFIX: Klinki Forestry Project	Forestry/Land Use—Forest management
Project CARFIX: Sustainable Forest Management	Land Use
Tierras Morenas Windfarm Project	Renewable Energy—Wind
Aeroenergía Wind Facility Project	Renewable Energy—Wind
BIODIVERSIFIX: Forest Restoration	Forestry/Land Use—Tropical forest management and reforestation; wood
Doña Julia Hydroelectric Project	Renewable Energy—Hydropower
Czech Republic	
Fuel Switching and Cogeneration for Decin District Heating System	Energy Use
Ecuador	
Forest Conservation Bilsa Reserve	Forestry/Land Use—Forest management and conservation
Honduras	
Bio-Gen Biomass Power-Generating Project	Renewable Energy—Biomass
Phase 1, Guaimaca Site	
Phase 2, Sava Site	
Solar-Based Rural Electrification in Honduras	Energy Use
Indonesia	
Reduced-Impact Logging in Kalimantan	Forestry/Land Use—Forest management; wood
Mexico	
Scolet Té—Sustainable Land Management and Carbon Sequestration	Multicomponent Forestry
Halophyte Cultivation in Sonora	Renewable Energy—Biomass
Nicaragua	
El Hoyo Monte Galán Geothermal Project	Renewable Energy—Geothermal
Panama	
Commercial Reforestation of Chiriqui Province	Forestry/Land Use—Reforestation
Russian Federation	
District Heating Improvements in Zelenograd	Energy Efficiency—Industrial/HVAC
RUSAFOR: Saratov Afforestation Project	Forestry/Land Use—Afforestation
RUSAGAS: Fugitive Gas Capture Project	Energy Efficiency—Fossil fuels; natural gas; energy intensity
Reforestation in Vologda	Forestry/Land Use—Reforestation

Stage of Activity ¹	Project Life ²	Greenhouse Gases ³ CO ₂ (MTs)	Other (MTs)
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In progress	40 yrs.	4,770,000	
Mutually agreed	30 yrs.	3,500,000	4,800 NO _x

In progress	30 yrs.	53,170,000	
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In progress	15 yrs.	263,000	
In progress	15 yrs.	1,267,000	
Mutually agreed	40 yrs.	6,970,000	
In progress	25 yrs.	21,780,000	
In progress	15 yrs.	187,000	
In progress	20 yrs.	36,000	
In progress	50 yrs.	18,500,000	

In progress	15 yrs.	210,000	
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In progress	25 yrs.	605,000	
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In progress	25 yrs.	1,600,000	
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Mutually agreed	Over 20 yrs.	2,300,000	
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Mutually agreed	20 yrs.	17,000	
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Mutually agreed	40 yrs.	207,000	
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In progress	30 yrs.	843,000	
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In progress	Soil carbon storage, over 10 yrs.	2,400	
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Mutually agreed	35 yrs.	19,770,000	
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Mutually agreed	25 yrs.	213,000	
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Mutually agreed	30 yrs.	1,613,000	
In progress	60 yrs.	128,000	
Mutually agreed	25 yrs.		1,220,000 tons CH ₄
Mutually agreed	60 yrs.	880,000	

¹ The following definitions are used for these categories:

- Mutually agreed = Accepted USJJI proposal; all Parties involved (designated national authorities) have agreed on activity.
- In progress = Any stage of activity between "mutually agreed" and "completed."
- Completed = Project is finished or terminated.

² Project life refers to the estimated functional lifetime of the project, not necessarily the period over which greenhouse gas reductions are estimated to occur.

³ Reduction estimates are made by project developers. The USJJI program does not accept these estimates per se, but will be monitoring and verifying emission reductions as they are attained.

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.

continued

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).

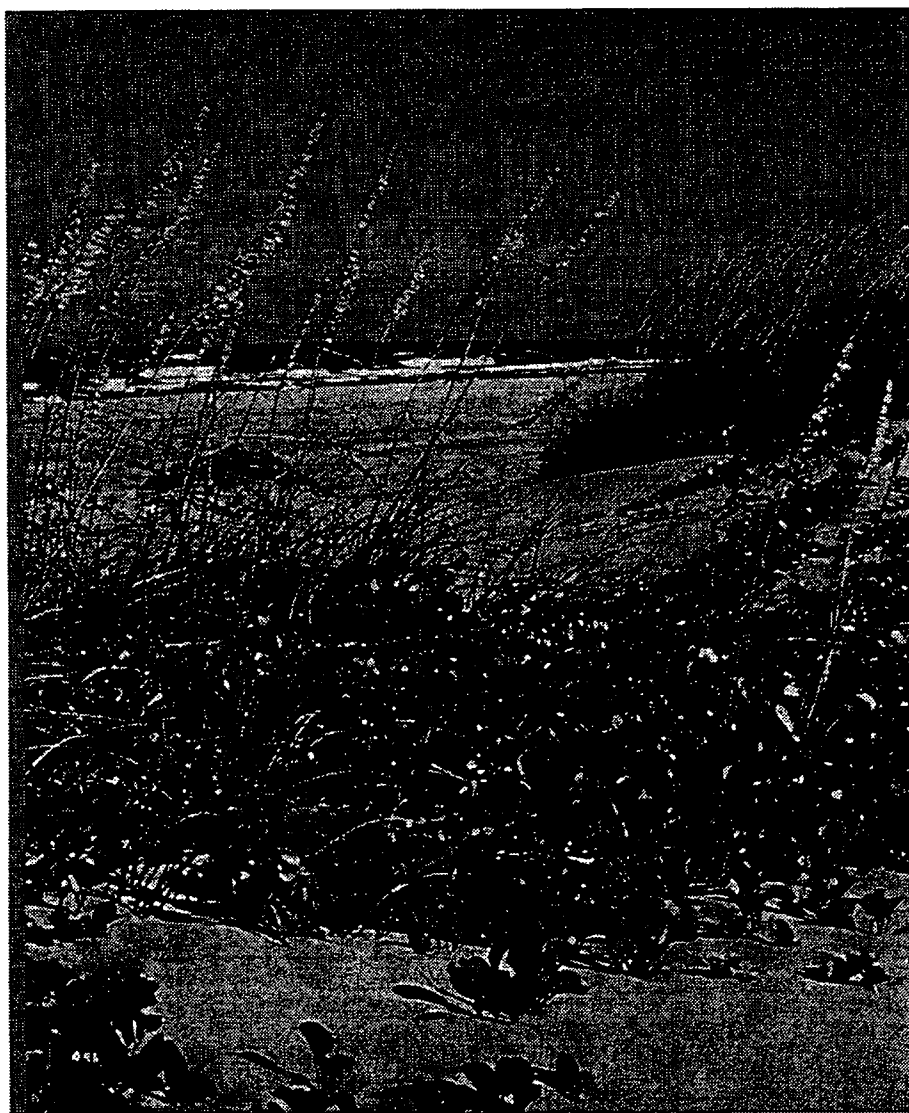
B. Summarize non-AIJ activities.

Conferences/Workshops

- January 1995: *Jl Southeast Asia Regional Workshop*, Bangkok, Thailand.
- March 1995: *Jl Central and Eastern Europe Workshop*, Prague, Czech Republic.
- March 1995: *Jl 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: *Jl 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 *Jl 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 *Jl 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, *Jl Online*, which can be accessed at <http://www.ji.org>
- Published a draft resource document: *USJI Project and Proposal Development*.



The Earth's climate has warmed about 0.5°C (0.8°F) over the last century, and is expected to warm another 1.5-3.5°C (2.5-5.8°F) over the next century under "business as usual" scenarios. Though the Framework Convention on Climate Change (FCCC) will affect future greenhouse gas emissions and the magnitude and rate of additional climate change, it cannot offset all stresses resulting from human influences, such as pollution, increasing resource extraction, and nonsustainable management practices (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.

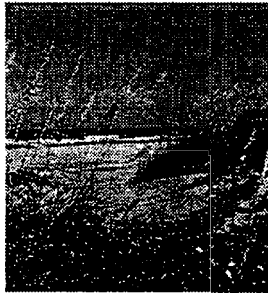
vulnerability and adaptation



- *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.

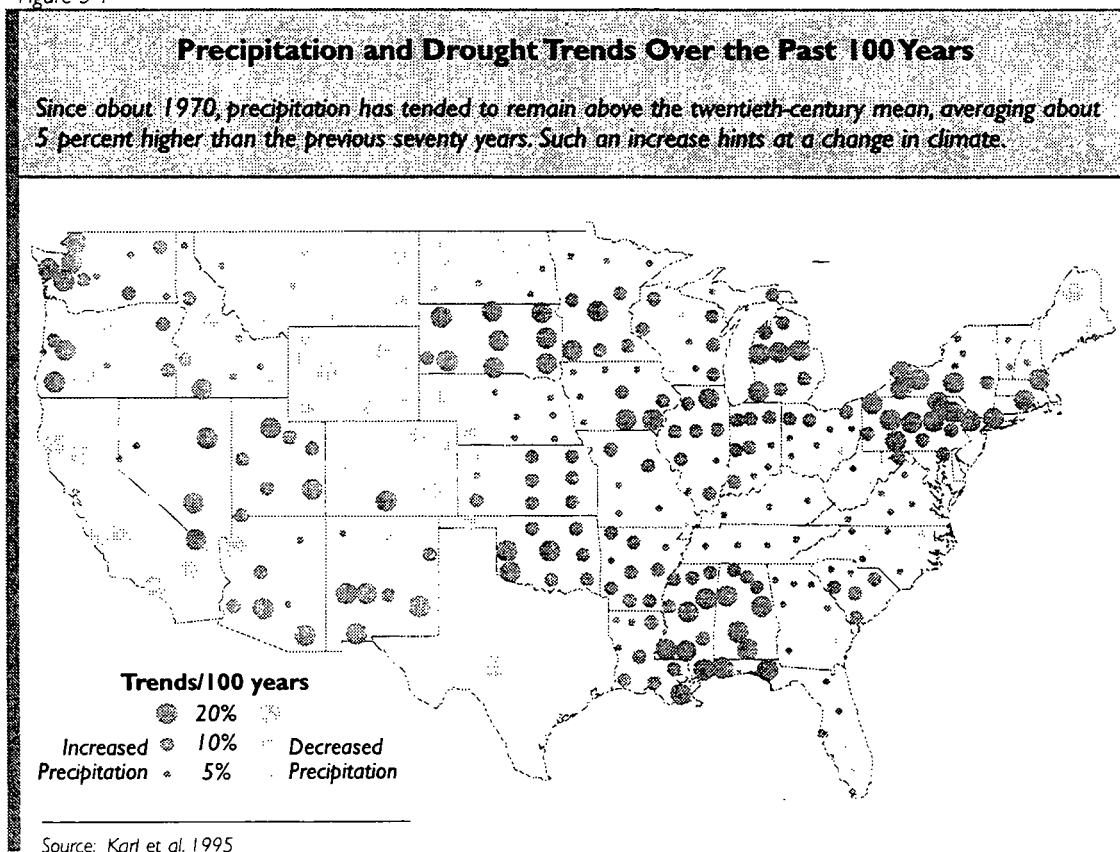
For example, following the Great Midwest Flood of 1993, the Scientific Assessment and Strategy Team was assembled from more than a dozen federal agencies. This multidisciplinary team of experts recommended a new approach—managing the Mississippi River Basin floodplain as a system rather than as a patchwork 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

Figure 5-1



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.

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 do.

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 recommenda-

tion 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.

Assessing the Regional Implications of Global Change

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 1998 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) and "lightly managed" systems (e.g., parks and undeveloped land) are far more adaptable to climate change than are natural ecosystems (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. Agri-

cultural 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, over-subscribed 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 Niño 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.

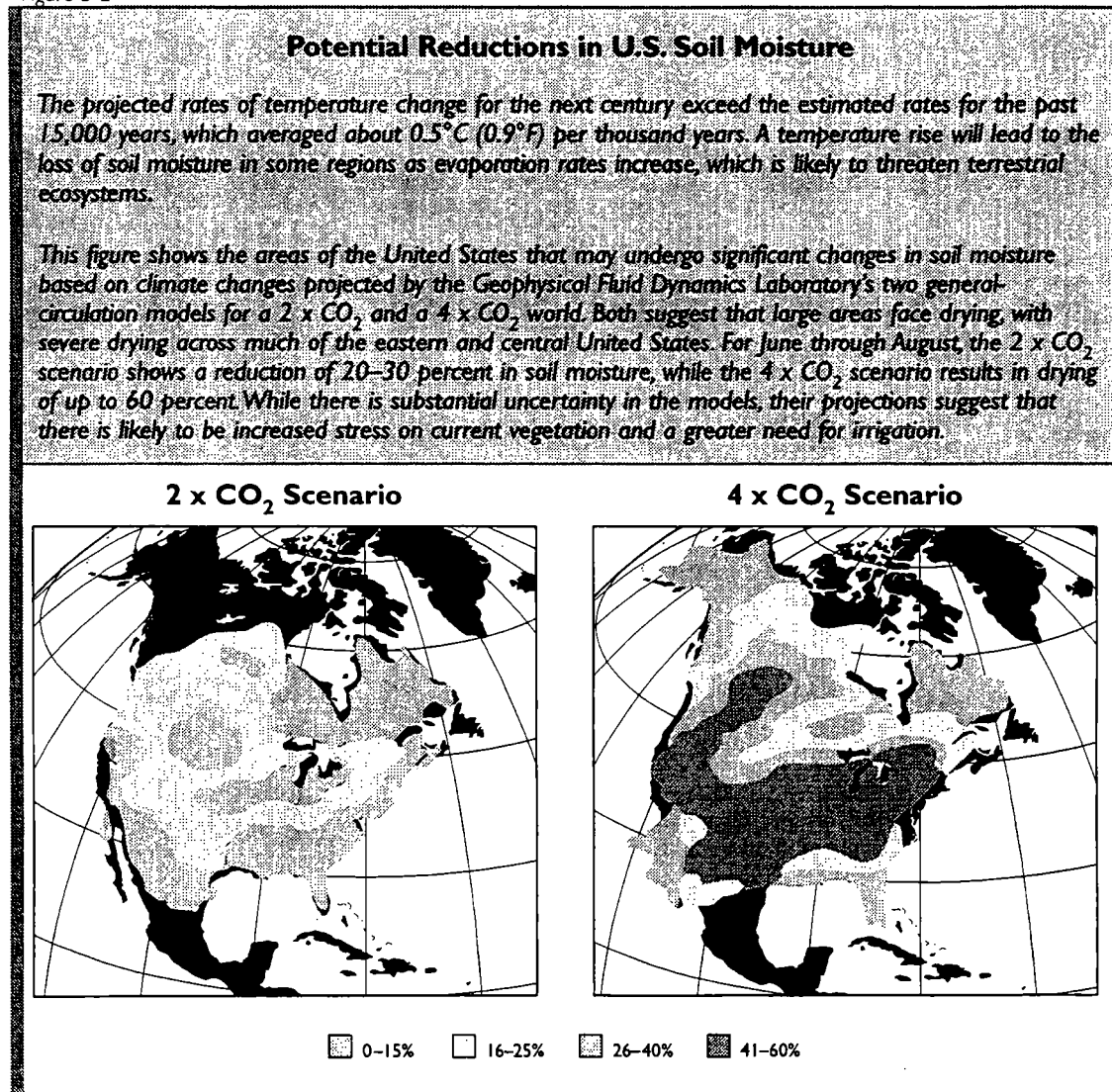
The 1994-97 period saw a significant rise in the number and scope of federal, state, and local efforts to integrate climate variability and its impacts on water supplies into the planning, design, and management of water-

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.

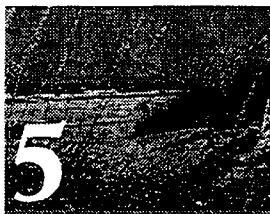
For example, the winter storms of December 1996 and January 1997 created flood conditions in several western states, disrupting water-treatment facilities and con-

taminating 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.

Figure 5-2



Source: xxxx



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 non-structural 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

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 (CWWP 1996). Among the report's conclusions is that the steep altitudinal gradient in these parks makes them highly vulnerable to climate change.

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 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.

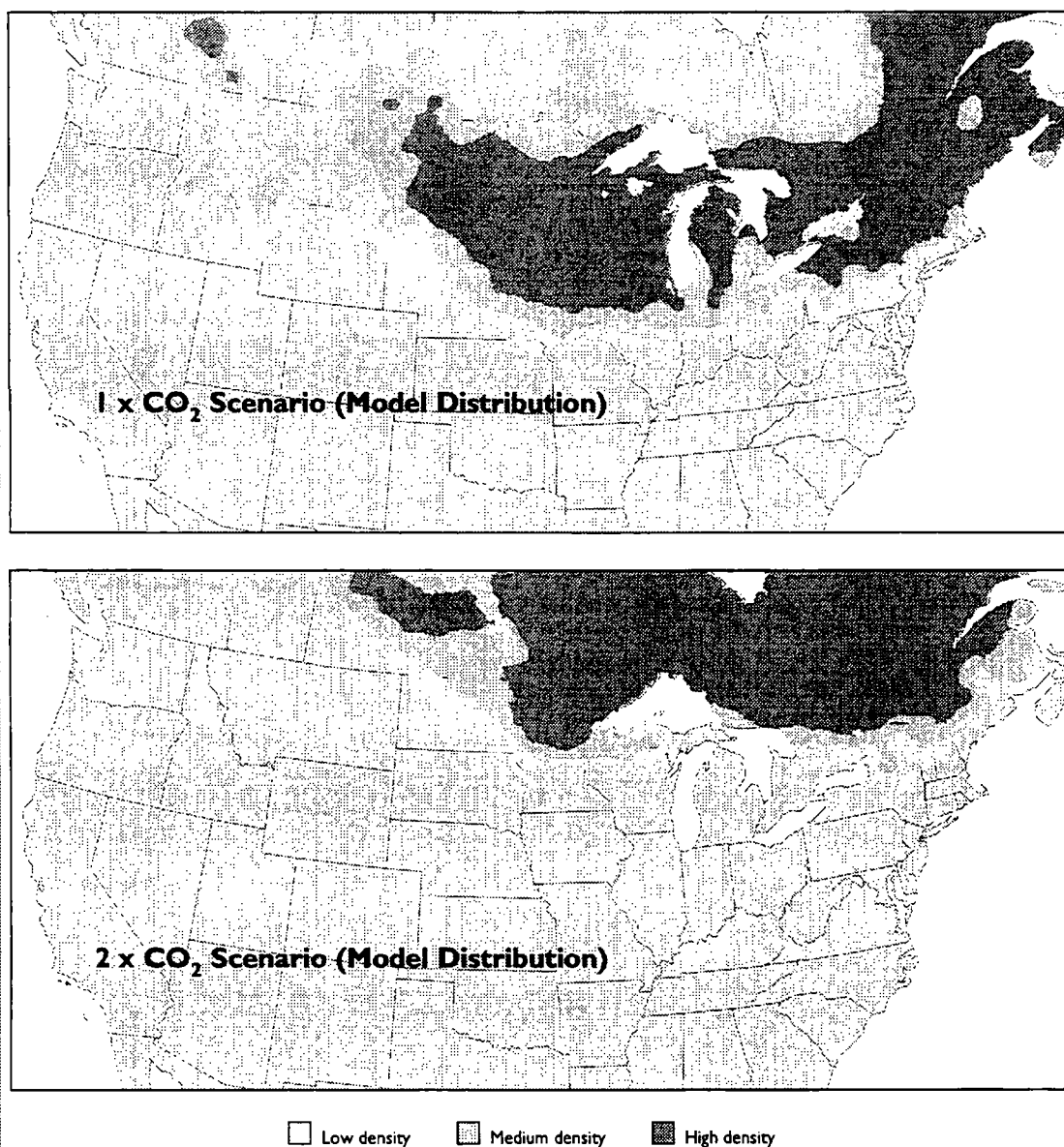
Through its Man and the Biosphere Program, the United States is also assisting in the development of the Biosphere Reserve Integrated Monitoring Network in Europe and North America. This pilot program establishes electronic linkages among the 170 biosphere reserves in Europe and North America for monitoring 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:

Figure 5-3

Bobolink Bird Distribution Under a 2 x CO₂ Scenario

Global climate change will cause rising temperature, changes in precipitation, and shifts in vegetation, making habitats unsuitable for various plants and animals. Based on simulations with an observationally based model that closely matches the current summertime distribution of bobolinks, the changes in climate conditions that would result from a doubling of atmospheric CO₂ concentrations are predicted to cause this migratory North American songbird to relocate northward.



Source: Schneider and Root 1997



- *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.

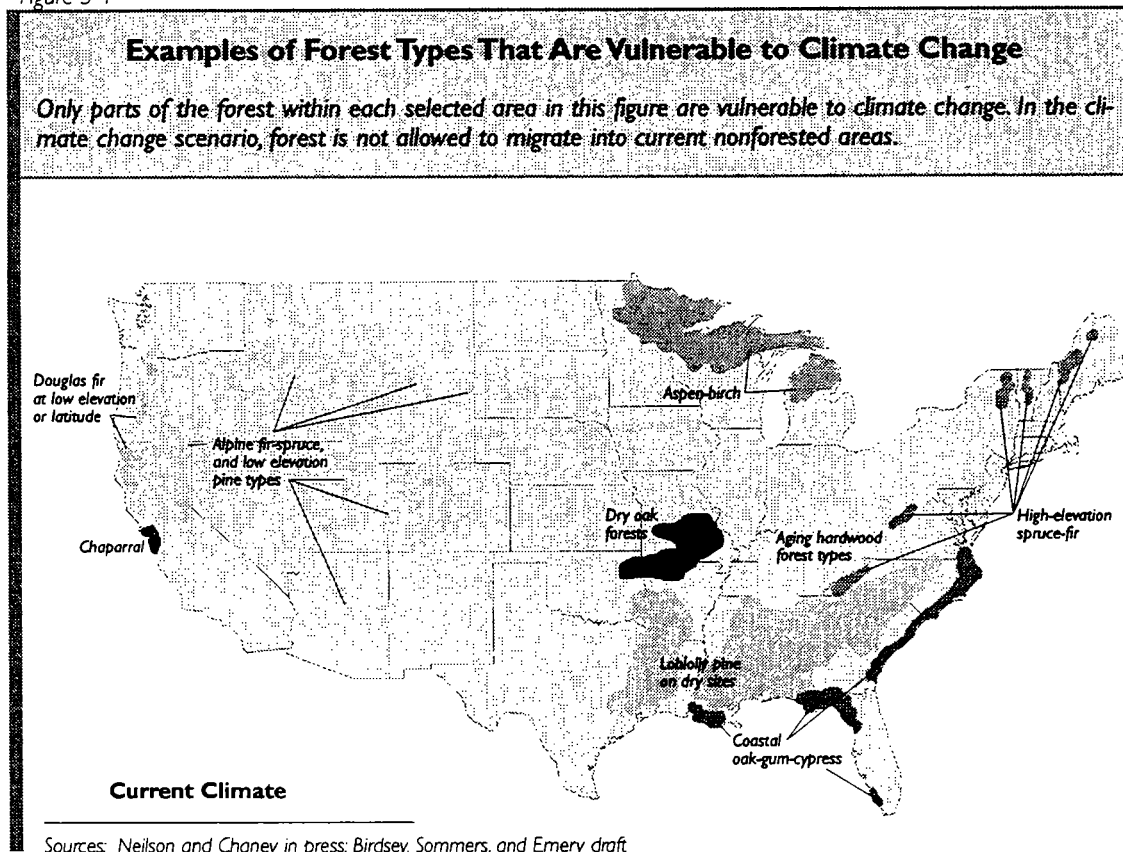
In addition to these agency programs, a partnership of seven federal agencies is contributing to this ecosystem research and assessment effort through a National Environmental Monitoring and Research Initiative, which will provide a comprehensive evaluation of our nation's environmental resources and 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.

Figure 5-4



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 may raise annual temperatures, potentially changing 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. Stud-

ies 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 arboreturns, 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 pres-

ures 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 base-

line 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.

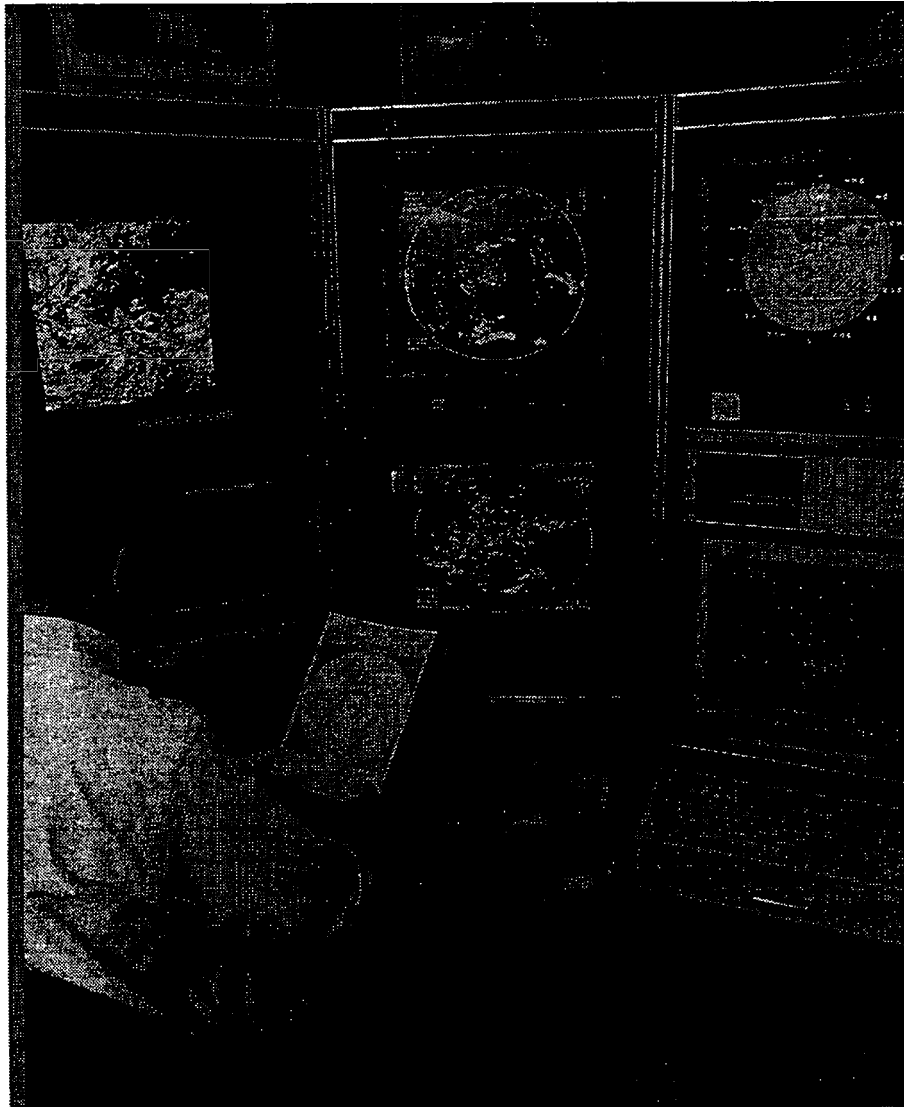
Adaptation Strategies

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, NTSC and the National Academy of Sciences published the second report in a series entitled *Proceed-*

ings of the Conference on Human Health and Global Climate Change (NTSC/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.





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:

... 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.

research and systematic observation

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 2.0–6.5°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

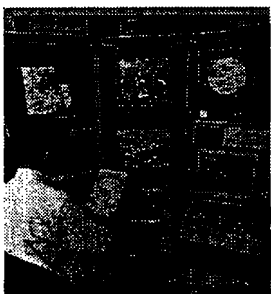
Key Findings of the IPCC's 1995 Second Assessment Report (continued)

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 unsustainable 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.



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

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.

volcanic and solar variability will also be carried out to document the natural factors that influence climate.

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 comprehen-

sive 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 natural sciences 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 mea-

surements 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.

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 Mis-

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.

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 AMI and PMI 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.

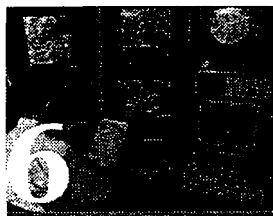
sion to Planet Earth and NASA's contribution to the Research Program. The NOAA and DoD contributions will be made through their operational weather satellite programs, a future component of which is being coordinated through the National Polar-Orbiting Environmental Satellite System program. (Because 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 net-

works. 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.

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;

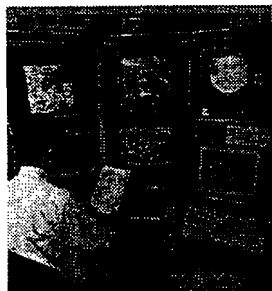


- the internationally sponsored array of moored and drifting buoys that monitor surface and subsurface temperatures in the tropical Pacific Ocean to help detect the onset of El Niño events;
- the U.S. Department of Agriculture (USDA), Department of the Interior (DOI), and EPA networks that monitor the 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.

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

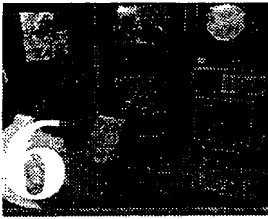
The IPCC estimates that climate change is likely to add 15–95 centimeters (about 6–38 inches) to sea level by the year 2100. The United States is involved in research to further quantify sea level rise, its effects, and possible adaptive responses. Some monitoring of current trends is under way: gauges 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 cli-

mate-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 pre-

vention 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

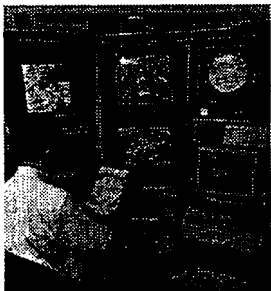
The El Niño/Southern Oscillation (ENSO) cycle is an oscillation of relatively warm and cold waters, with available periods of two to seven years. The ENSO cycle influences the frequency, severity, and paths of storms in the Pacific Ocean, the viability of commercial fisheries off the coast of South America, 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 inter-annual 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 appli-

cation 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.

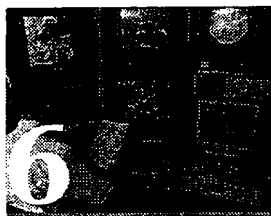
Energy Efficiency Research

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.

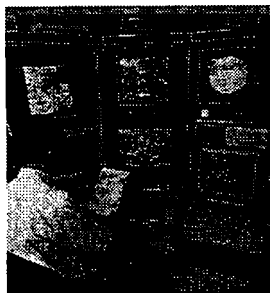
High TEWI (Total Equivalent Warming Index) Refrigerants

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

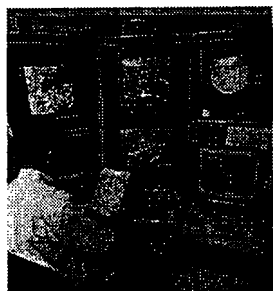
change, and in setting priorities for climate change research.

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;

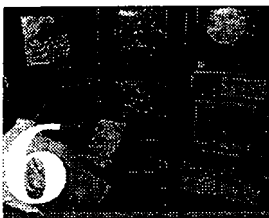
have developed the scientific rationale and plans for resolving these problems; and are providing an international framework within which research activities sponsored by the U.S. Global Change Research Program can both address national research objectives and provide key contributions to coordinated 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 biol-



ogy 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 envi-

ronmental 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

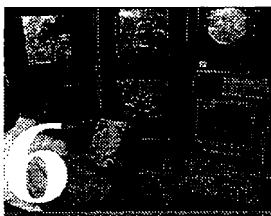
insight into how society might adapt to longer-term climate change.

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 GCRI 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. GCRI 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, institu-

tions, 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.



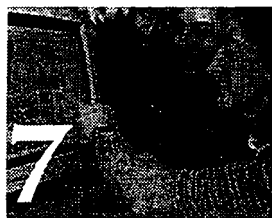


Global climate change is increasingly an essential part of the context in which social, economic, and technological development takes place. Yet most U.S. citizens are unaware of this phenomenon and its impacts. Societal decision making needs to be based on an informed understanding of the factors driving 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

education, training, and outreach



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 and 1990, and the Environmental 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

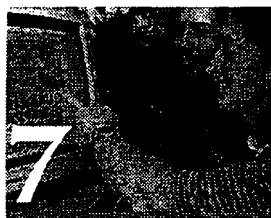
This National Aeronautics and Space Administration (NASA) program is intended to substantially improve understanding of the natural processes that govern the global environment and to assess the effects of human activities on these processes. It is expected to yield improved weather forecasts, tools 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, non-profit organizations, White House inter-agency 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.

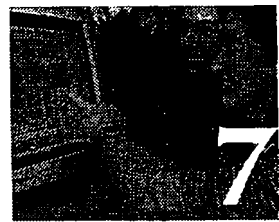
Outreach

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, non-governmental 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 emission 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: emissions cap and trade, 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 MTPE'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.



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, government, and 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 global change and sustainability. 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* is designed to serve as a model for projects, programs, and opportunities that will encourage education for sustainability as a critical part of a lifelong learning process.

PCSD established an Education Working Group (EWG) to support partnerships among the education and extension net-

works, 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, development of an Executive Order on education for sustainability, coordination and implementation of education for sustainability programs, and a mechanism for providing input to the Interagency Working Group on Sustainable Development Indicators.

The PCSD's Office of Education for Sustainability will report on the status and future of education for sustainability, provide technical assistance to education leaders, manage federal interagency working groups, promote linkages with PCSD task forces and working groups, and coordinate 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 proposed School Construction Initiative provides for \$5 billion in federal subsidies for new school construction and renovation bonds over the next four years, with an estimated 25 percent projected savings of the current energy budget.

The President's Council on Sustainable Development (PCSD) will continue to work with EPA to investigate the possibilities for regulatory streamlining incentives for schools to provide superior environmental performance. PCSD and EPA will also explore the possibilities for granting tradable emission-reduction credits for community initiatives in land-use planning.

PCSD 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 life-long 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 Office of Education for Sustainability 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 global climate change education, training, and outreach programs 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 global climate change 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.





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

international activities



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 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 vulnera-

bility 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

Figure 8-1



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 (USIJI) pilot program in October 1993 as part of the U.S. *Climate Change Action Plan*. To date, the USIJI 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 USIJI in greater detail.

Worldwide Projects

Some of the U.S. development assistance programs related to climate change have

partners around the world. Nearly all of them are in the field of energy efficiency or renewable energy. 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 non-governmental 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 capac-

ity 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 lev-

els, 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 un-

familiarity 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, \$1.5 million, 1994–1997, 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

Building Measurement and Verification Protocol

The present low level of energy-efficiency investments is an important market failure. Barriers to energy-efficiency financing include the unreliability of energy savings, high transactions costs (because most transactions are conducted differently), and the inability to bundle transactions because there is no standard approach to developing energy-efficiency investments.

To overcome these barriers, in 1994 DOE initiated a public-private partnership among U.S., Canadian, and Mexican industry and energy organizations and several finance firms to develop a national and international standard on how to implement, measure, and verify efficiency savings. Published in early 1996, the result of this collaboration—the Building Measurement and Verification Protocol—has been widely adopted in the United States, Canada, and Mexico and is being translated into Russian, Portuguese, French, Spanish, and Hungarian.

A growing range of governments, businesses, and NGOs is joining the protocol development process to refine and extend its application. Recently, DOE has helped the World Bank structure \$350 million in new financing for large-scale efficiency projects that require use of the protocol, and is developing other joint projects.



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 sugarcane 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 demon-

strations 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

Sustainable Energy Cooperation in the Western Hemisphere

Following up on the 1994 Summit of the Americas hosted by the United States, the U.S. Department of Energy and the Venezuelan Ministry of Energy and Mines established a cooperative process to implement the Summit of the Americas energy action plan. The action plan outlines commitments designed to promote increased sustainable energy development in the Hemisphere, including increased investment in renewable energy, energy efficiency, and cleaner conventional energy sources. Eight working groups were established, each with a country or organizational lead.

The working group on energy efficiency, led by Brazil, has established a framework for information exchange, including a Hemispheric Efficiency Homepage. DOE and Natural Resources Canada have encouraged a focus on standards, labeling, and codes, with potential to move toward harmonization. Canada will host a Hemispheric conference on harmonization early in 1997 to further the dialogue toward regional cooperation on standards for energy efficiency. Harmonization will facilitate trade and equipment compatibility, and standards are the easiest and least-cost first step to increase energy efficiency.

The World Bank, United Nations Development Program, and the Inter-American Development Bank signed a joint statement at the October 1995 Hemispheric Energy Symposium outlining their commitment to support the activities of the Hemispheric Energy Ministers in promoting sustainable energy development. As the lead for the financing working group, and at the request of the energy ministers, DOE is currently summarizing the available funds for clean-energy technologies, so that partner governments can more readily access funding for clean energy projects.

In addition to the Hemispheric cooperation, bilateral and regional partnerships are helping to lead to policy and regulatory changes to provide a level playing field to more environmentally sound energy technologies, including renewable-energy and energy-efficiency investments. Increased awareness among countries in the Hemisphere, falling prices of relevant technologies, and greater private-sector interest and engagement have all encouraged governmental leadership to promote more environmentally sound energy development.

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 suppli-

ers 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 Sahelianiza-

tion; (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 demon-

strates 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 collabora-



tion 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 sec-

tor. 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 for-

mulation 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 \$1.3 billion for 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 non-governmental sources, the United States is the second largest contributor to the Operation Phase to date, with \$190 million. The United States currently has accrued overdue commitments to the GEF due to 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 develop-

ment. 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 mitiga-

tion 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 (CADDET) 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

EEl 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, EEl 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 foun-

dations 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.

**appendix a:
climate plan actions**

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 program is 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 maximize cost-effective investments in energy efficiency for 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 to energy-efficiency investments made by small and large businesses and by state and local governments. 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 building electricity consumption, 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.

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

Contact: Maria Tikoff, EPA, Atmospheric Pollution Prevention Division, 202-233-9190.

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, and cooking.

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 MMTCE 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 703-287-8394 (International).

Energy Partnerships for Affordable Housing

(Climate Plan Action 8 & 11)



This initiative is part of 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 703-287-8394 (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).

Construction of Energy-Efficient Buildings



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. These new buildings are projected to be responsible for 50 MMTCE of greenhouse gas emissions in 2010. 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 is currently limited to retrofits to existing buildings. Under this action, the agencies will jointly develop a program that most effectively improves energy use in new buildings.

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 703-287-8394 (International).

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 dedicate 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.

Fuel Cells

(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 lightweight, 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 703-287-8394 (International).*

Motor Challenge

(Climate Plan Action 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 1.7 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 Motor-Master 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 703-287-8394 (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 (N_2O) from microbial activity occurring in the soil and lower CO_2 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 N_2O emissions from agricultural soils under a range of management and weather conditions. Field testing of the model in Colorado has shown that simulated N_2O 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 N_2O 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.

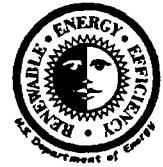
Achievements

- 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 703-287-8394 (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 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 (a 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 1.0 MMTCE.
- 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, Producer Program, 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 works with these "Allies" to disseminate reliable information, identify project opportunities, and create 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 are jointly supporting 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 will support partnership teams, led by the coal industry, who will develop 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, are working jointly to maximize methane gas use and recovery from landfills.

The Solid Waste Management Association of North America (SWANA) is 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, 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 703-287-8394 (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 20 partners, representing more than 100 farms. The program also has 31 Allies, representing system and equipment manufacturers, educational institutions, state and local governments, consultants, 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, 202-233-9044; Barry Kintzer, USDA-NRCS, Conservation Engineering Division, 202-720-4485.

Improve Ruminant Productivity and Product Marketing

(Climate Plan Action 39)



In the year 2010, the Ruminant Livestock Efficiency Program is expected generate:

- Methane savings 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-expensive, 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.

Narrow Use of High Global Warming Potential Chemicals

(Climate Plan Action 40)



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, and
- voluntary partnerships with emitters to reduce pollution.

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.

PFCs and HFCs are intentionally used in the following three industries: (1) semiconductor production (SF_6 , CF_4 , C_2F_6 , C_3F_8 , NF_3 , and CHF_3); (2) electrical power systems (SF_6); and (3) magnesium casting (SF_6). Most emission reductions for these industries are believed to be possible through environmentally protective, cost-effective means. In all cases, the principles of pollution prevention are under consideration for reducing emissions.

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., SF_6 is an unacceptable substitute for aerosol propellants due to its very high GWP and the existence of other compressed gases that perform equally well).
- This action has initiated discussions of voluntary controls for PFCs and HFCs in the magnesium and electrical power industries.
- This action has also instituted the PFC Emission Reduction Partnership for the Semiconductor Industry. As of February 1997, 18 semiconductor companies (more than 60 percent of U.S. production) had joined the partnership to reduce emissions.

Contact: Elizabeth Dutrow, EPA, Atmospheric Pollution Prevention Division, 202-233-9061.

Expansion to CCAP Action 40: Narrow Use of High Global Warming Potential Chemicals and Stewardship

(New Climate Plan Action)



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

- Carbon-equivalent savings of 10.0 MMT

This action continues 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 (SF_6 , CF_4 , C_2F_6 , C_3F_8 , NF_3 , and CHF_3); (2) electrical power systems (SF_6); and (3) magnesium casting (SF_6). 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 SF_6 , with a GWP of 23,900 and an atmospheric lifetime of 3,200 years. It is used by all three industries. Atmospheric concentrations of SF_6 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 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 (CF_4) and carbon hexafluoride (C_2F_6) 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 CO_2 , 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 CF_4 and C_2F_6 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 CF_4 and C_2F_6 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 non-industrial 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 703-287-8394 (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 2.6 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; Climate Wise Line, 1-800-459-WISE.

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>.

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>