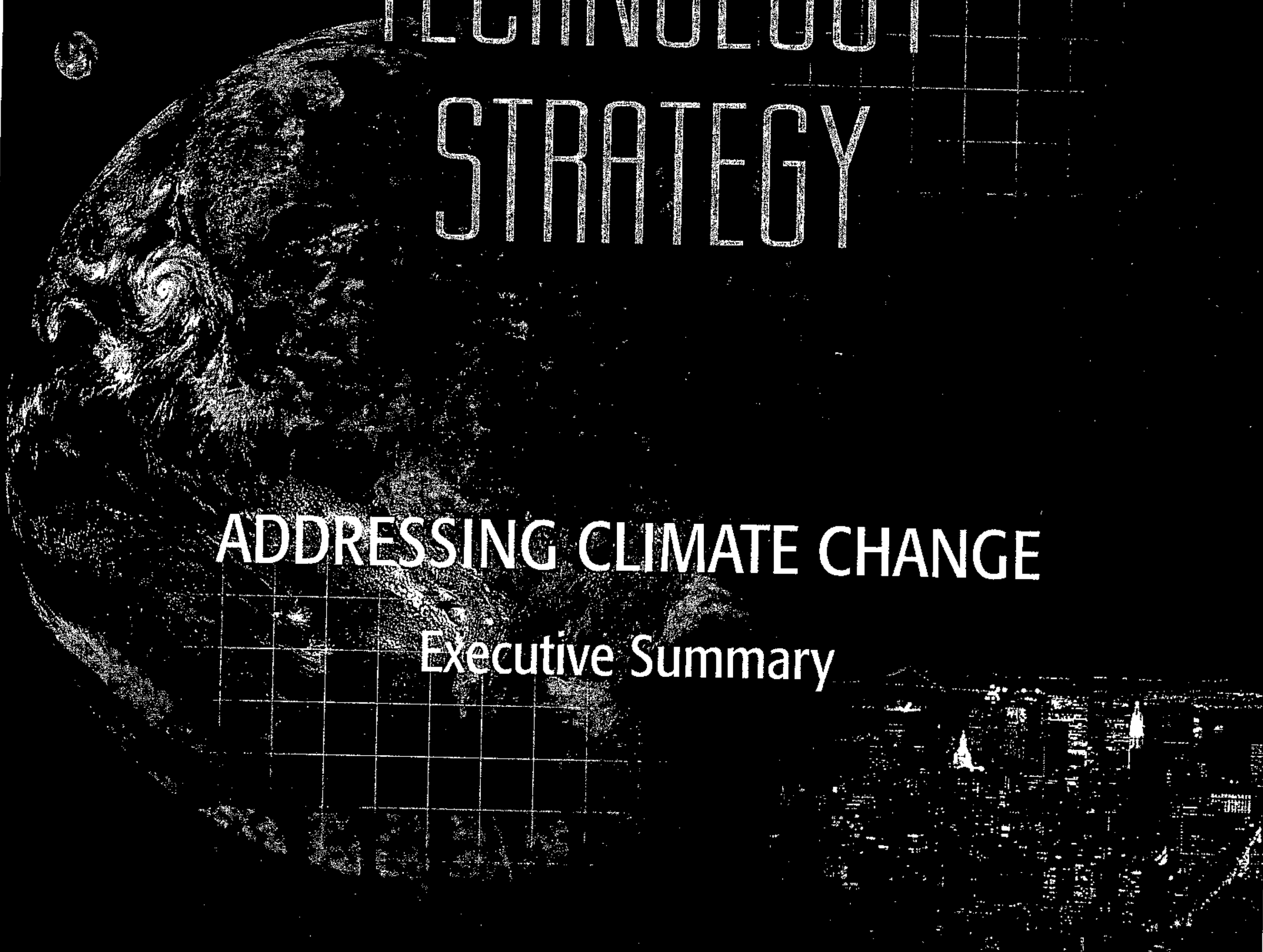
GLOBAL ENERGY TECHNOLOGY STRATEGY



ADDRESSING CLIMATE CHANGE

Executive Summary

Initial Findings from
an International Public-Private Collaboration

Global climate change is one of the most complex environmental, energy, economic, and political issues confronting the international community. The impacts of climate change are likely to vary considerably by geographic region and occur over a time scale of decades to centuries. The actions needed to manage the risks ultimately require substantial long-term commitments to technological change on the part of societies worldwide.

This report focuses on carbon dioxide, the greenhouse gas contributing the majority of the projected human influence on climate. Carbon dioxide emissions can affect the atmosphere for hundreds of years. Some of the carbon dioxide emitted in 1800 is still in the atmosphere—and today's emissions will continue to influence climate in 2100. The total concentration of carbon dioxide in the atmosphere at any given time is much more important in determining climate than are emissions in any single year. Limiting the human impact on the climate system therefore requires that atmospheric concentrations be stabilized.

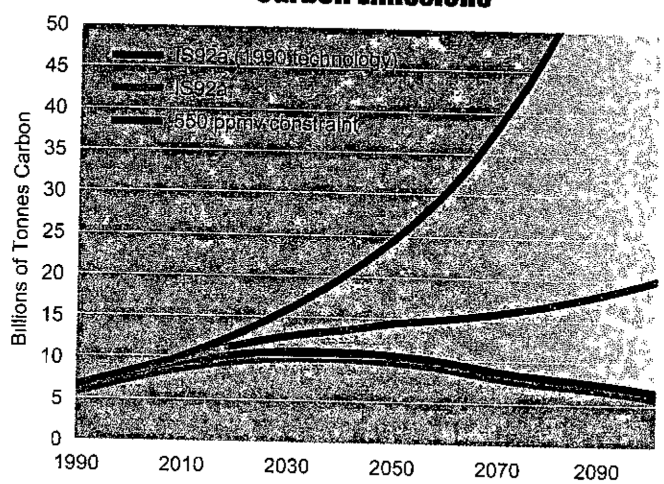
The Challenge

The Earth's climate is governed primarily by complex interactions among the sun, oceans, and atmosphere. The increased concentration of heat-trapping "greenhouse gases" in the atmosphere has led to concerns that human activities could warm the Earth and fundamentally change the natural processes controlling climate.

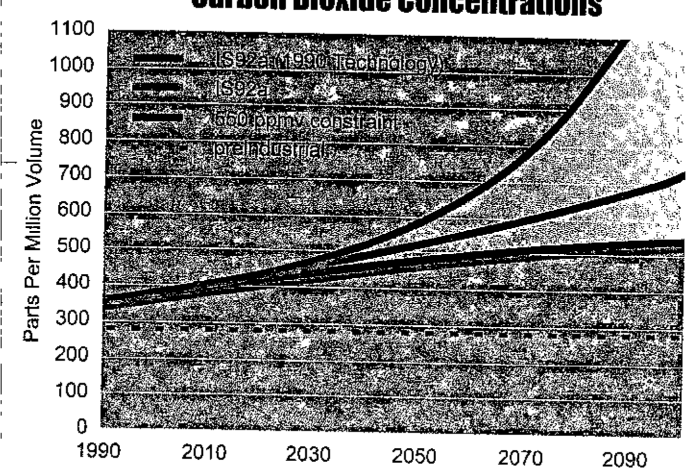
The middle curve in the first chart depicts the carbon dioxide emissions associated with the Intergovernmental Panel on Climate Change (IPCC) central scenario, denoted IS92a, and the middle curve in the second chart represents the concentrations in the atmosphere that result from these emissions. This IPCC "business-as-usual" scenario incorporates significant technological advances. In contrast, while the top curves assume the same population and economic growth as IS92a, they hold energy technology constant at its 1990 level. The difference between the upper and middle curves thus illustrates the technological improvement needed merely to achieve the IS92a emissions path with its corresponding impact on concentrations. The lower curves depict an emissions path and its corresponding concentration path consistent with a 550 parts per million volume (ppmv) concentration ceiling. The dotted line on the concentrations chart indicates the pre-industrial level of carbon dioxide concentrations (i.e., a level virtually unaffected by human activities).

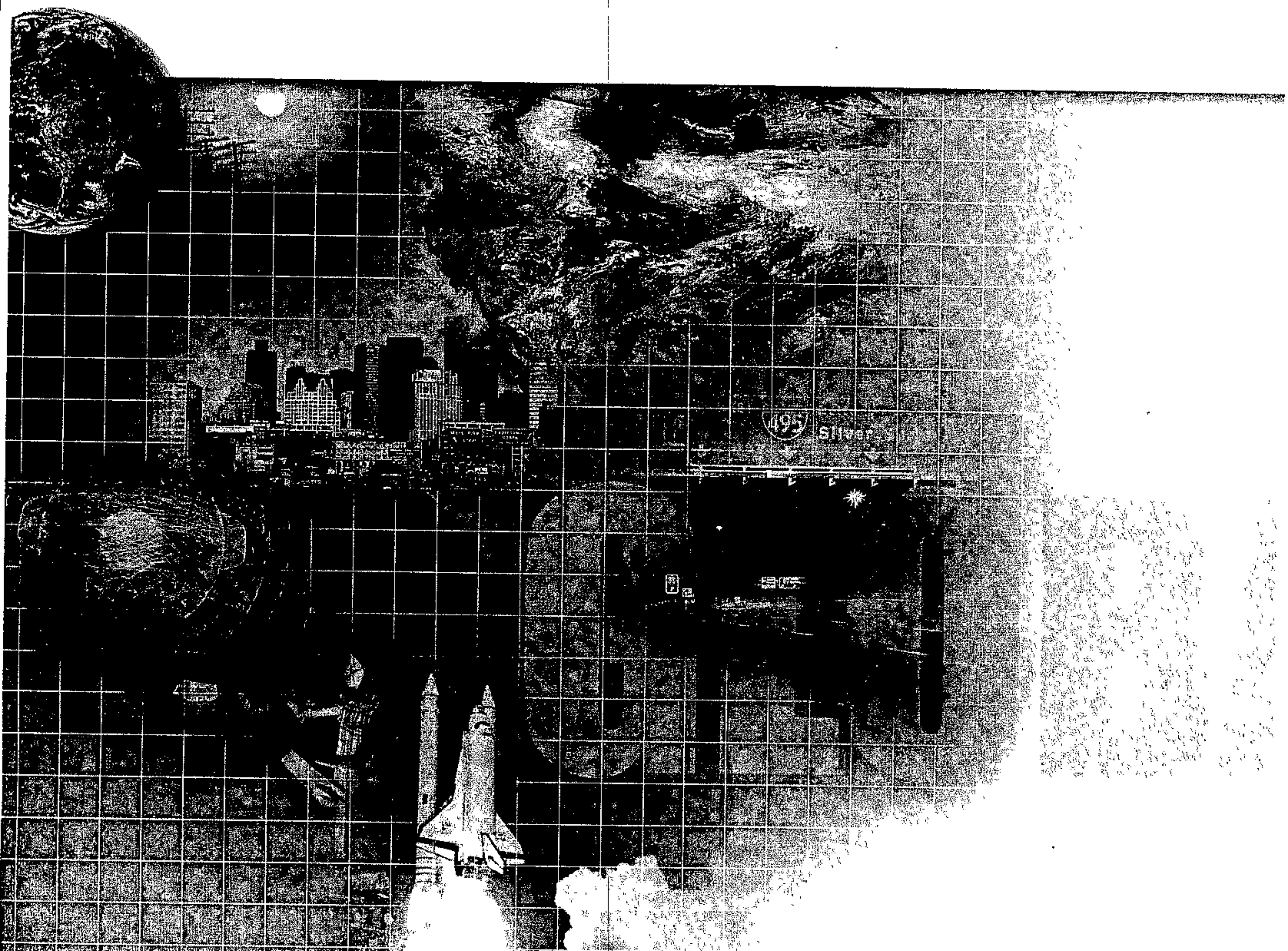
The Future With and Without Technological Change

Carbon Emissions



Carbon Dioxide Concentrations





Energy Technology Strategy

Fundamental changes in the energy system are required to stabilize concentrations of greenhouse gases in the atmosphere. Incremental improvements in technology help, but will not by themselves lead to stabilization.

A technology strategy is an essential complement to national and international policies aimed at limiting emissions, enhancing adaptation, and improving scientific understanding. A technology strategy will provide value by reducing costs under a wide range of possible futures, which is essential given the uncertainties in the science, policies, technologies, and energy resources. The lack of a technology strategy would greatly increase the difficulties of addressing the issue of climate change successfully.

The findings and recommendations of the Global Energy Technology Strategy Program, listed below, represent an initial attempt at delineating the elements that will be needed to guide the development of a technology strategy to address climate change.

Key Findings

Stabilizing concentrations of greenhouse gases in the atmosphere requires fundamental change in the energy system.

Energy is central to the climate change issue. Carbon dioxide emissions from the production and consumption of fossil fuels are the largest contributor to human emissions of greenhouse gases. Fossil fuel resources are abundant, and, if used in conjunction with present energy technology, have the potential to increase the concentrations of greenhouse gases in the atmosphere substantially.

If present trends continue, carbon dioxide emissions from energy will continue to grow. The influences of future population growth and economic development on the demand for energy services are likely to exceed currently projected improvements in energy intensity and the ongoing transition to less carbon-intensive fuels. However, trends are not destiny—a global technology strategy could help change the present course.

In order to stabilize concentrations of greenhouse gases in the atmosphere, global carbon emissions must peak during the 21st century and then decline indefinitely. This can occur only if lower carbon-emitting technologies are deployed worldwide.

Technology breakthroughs are essential both to stabilize greenhouse gas concentrations and to control costs.

Although incremental technology improvements are essential, they will not lead to stabilization. Even with significant improvements in the performance of existing commercial technologies, the concentration of carbon dioxide in the atmosphere would grow to more than 2.5 times pre-industrial levels by 2100.

Technology breakthroughs can reduce the cost of greenhouse gas stabilization dramatically. Technological advances can reduce the annual cost of stabilizing atmospheric concentrations of greenhouse gases by at least 1-2 percent of gross world product. The savings will depend upon the concentration target and the level of technology improvement.

It is time to get started. The energy system is capital-intensive, and the development and deployment of new technologies can take decades. Given the lead-time necessary to develop and deploy new technologies with their associated systems and infrastructure, we must begin the process without delay.

A portfolio of technologies is necessary to manage the risks of climate change and to respond to evolving conditions.

A diversified portfolio accommodates future uncertainties. Changing scientific knowledge and economic conditions, combined with uncertainty in the resource base, requires a diversified initial portfolio of technology investments. Portfolio investment priorities will evolve over time as these uncertainties are resolved.

A broad portfolio can control costs. A portfolio encompassing a broad suite of technologies can lower the costs of stabilization significantly. However, the public and private sectors cannot fund every idea. Technology investment priorities must be established to reflect available funding.

A broad portfolio can meet the differing needs of key regions. Countries will need and employ different technologies based on their geography,

Improve the implementation and performance of energy research and development.

Incorporate climate change when revisiting current energy research and development priorities.

Better coordinate the roles of the public and private sectors in the research and development process to reflect their specific strengths.

Fund all stages of the innovation process from basic research to market deployment of the most promising technologies.

Establish long-term goals and near-term milestones for technological performance to drive progress and to maximize returns on technology investments.

Design flexible research and development programs to allow for the shifting of resources to accommodate new knowledge and conditions, particularly when sufficient technological progress is not being achieved.

Reflect the international nature of the research challenge.

Develop and coordinate international and national energy technology research and development strategies to take advantage of national scientific strengths and regional needs.

Provide assistance to key developing countries to build their technical and institutional capacities for implementing energy research and development programs effectively and for deploying advanced technologies.

Project Coordinators

Dr. James A. Edmonds
Battelle
901 D Street, SW, Suite 900
Washington, DC 20024
202-646-5243 (tel)
202-646-5233 (fax)
jae.edmonds@battelle.org

Dr. John F. Clarke
Battelle
901 D Street, SW, Suite 900
Washington, DC 20024
202-646-5280 (tel)
202-646-5233 (fax)
john.clarke@battelle.org

The Global Energy Technology Strategy Program's website provides access to the technical papers that form the basis of the analyses presented in this report. References for the Global Energy Technology Strategy Addressing Climate Change may be found on the website: http://gtsp.battelle.org.

In 1998, Battelle, together with EPRI, established the ***Global Energy Technology Strategy Program*** with the aim of assessing the role that technology can play in addressing the long-term risks of climate change. Led by a core group of Battelle scientists, the program benefits from analyses and insights provided by a network of partner institutions around the world. The process is guided by an international steering group representing diverse perspectives and is funded by government agencies, research institutions, and private industry. The views and opinions expressed herein do not necessarily state or reflect those of the sponsoring or participating institutions.

Photo Credits: Earth images, NASA; city, Melody Warford; all other images, Department of Energy.

indigenous resources, and economic, social, and political systems.

A flexible portfolio can accommodate alternative policy responses to the climate issue. A technology portfolio complements a wide range of possible national and international policies, including trading, taxes, and other policies and measures.

A broad portfolio also can reflect the diversity of the energy system. Technologies are needed to improve the efficiency of energy use, develop non-carbon energy sources, and limit the free venting of carbon from the fossil energy that will continue to be burned.

Current investments in energy research and development are inadequate.

Energy research and development outlays are declining. Both public and private sector investments in energy research and development have declined significantly since the 1980s.

Energy research and development expenditures are unfocused and poorly coordinated. Neither public nor private sector investments are adequately focused on the technologies that could be critical for stabilizing concentrations in the long term. Among the few governments with national energy research and development programs, investments are poorly coordinated and fail to take advantage of possibilities for joint, complementary, or specialized research.

Terrestrial sequestration, hydrogen, and carbon capture, use, and storage technologies potentially play an important role in stabilizing concentrations, but are currently funded at minimal levels.

Emissions limitations and controlling costs complement a technology strategy.

Emissions limits are needed to stabilize concentrations. Without such limits, individual nations have little incentive to reduce greenhouse gas emissions. It is unlikely that the required technologies to achieve stabilization will be developed and deployed if there is not any value placed on developing such technologies.

Controlling the costs of stabilization is necessary. The costs of stabilizing concentrations of greenhouse gases are uncertain and are distributed unevenly across generations, nations, and sectors of the economy. Better definition and control of these costs is critical to achieving societal consensus to take action.

Increase global investments in energy research and development

Increase investment in energy research and development to improve the performance of existing technologies and to develop the next generation of technologies that are required to stabilize greenhouse gas concentrations.

Develop dedicated long-term funding sources for energy research and development to support the necessary technology transformation.

Direct investments to specific technologies that have significant potential to substantially reduce greenhouse gas emissions over the long term.

Build broad-based public support by communicating the climate and ancillary benefits of energy research and development.

Recognizing this fact, more than 180 countries ratified the 1992 United Nations Framework Convention on Climate Change (FCCC), and it has entered into force under international law. The *ultimate objective* of this treaty is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." (Article 2)

The objective of the FCCC—stabilizing the concentrations of carbon dioxide and other greenhouse gases—is not the same as stabilizing emissions. Because emissions accumulate in the atmosphere, the concentration of carbon dioxide will continue to rise for several hundred years even if emissions are held at current levels or slightly reduced.

The FCCC process has not yet specified a particular target concentration. But in order to stabilize concentrations at any level ranging from 450 parts per million to 750 parts per million, very large reductions of worldwide emissions (from emissions that might be anticipated were present trends to continue) would be required during the course of the present century.

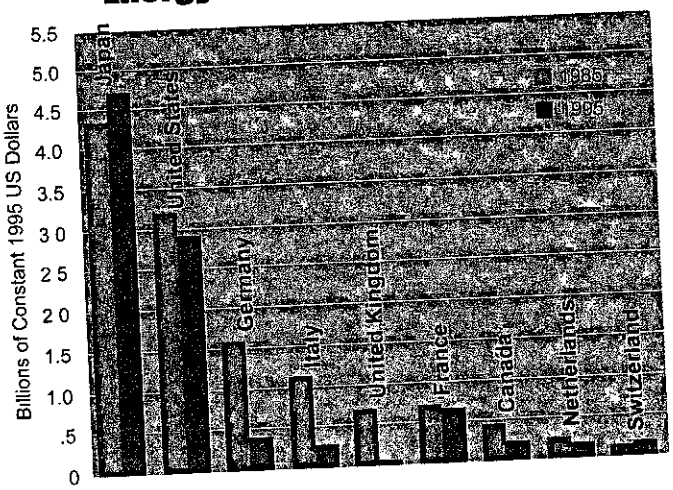
Technology is Critical

Energy is central to the climate issue. Energy use appears to be the primary contributor to the global increase in carbon dioxide concentrations. Increasing world population, together with the universal desire for economic development, will lead to growing demand for the products and services that the energy system provides. The future evolution of that system—dominated today by coal, oil, and gas—is the key determinant of the magnitude of future human influence on the climate.

Managing the risks of climate change will require a transformation in the production and consumption of energy. Technology is critical to such a transformation. Improved technology can both reduce the amount of energy needed to produce a unit of economic output and lower the carbon emissions per unit of energy used. Successful development and deployment of new and improved technologies can significantly reduce the cost of achieving any concentration target.

Recent trends in public and private spending on energy research and development suggest that the role of technology in addressing climate change may not be fully understood. Although public investment in energy R&D has increased slightly in Japan, it has declined somewhat in the United States and dramatically in Europe, where reductions of 70 percent or more since the 1980s are the norm. Moreover, less than 3 percent of this investment is directed at a few technologies that, although not currently available commercially at an appreciable level, have the potential to lower the costs of stabilization significantly.

Energy R&D Funding is Declining



Total public funding of energy research in the OECD is falling. Although Japan's outlays increased slightly, US spending declined and leading European nations reduced their funding dramatically.

Sponsors

Battelle Memorial Institute
BP
EPRI
ExxonMobil
Kansai Electric Power
National Institute for Environmental Studies (Japan)
New Energy and Industrial Technology Development Organization (Japan)
North American Free Trade Agreement–Commission for Environmental Cooperation
PEMEX (Mexico)
Tokyo Electric Power
Toyota Motor Company
US Department of Energy

Research Organizations

Core Institution

Battelle

Collaborating Institutions

Autonomous National University of Mexico
Centre International de Recherche sur l'Environnment et le Developpement (France)
China Energy Research Institute
Council on Agricultural Science and Technology
Council on Energy and Environment (Korea)
Council on Foreign Relations
Indian Institute of Management
International Institute for Applied Systems Analysis (Austria)
Japan Science and Technology Corporation
National Renewable Energy Laboratory
Potsdam Institute for Climate Impact Research (Germany)
Stanford China Project
Stanford Energy Modeling Forum
Tata Energy Research Institute (India)

Steering Group

Richard Balzhiser, President Emeritus, EPRI
Richard Benedick, Former US Ambassador to the Montreal Protocol
Ralph Cavanagh, Co-director, Energy Program, Natural Resources Defense Council
Charles Curtis, Executive Vice President, United Nations Foundation
Zhou Dadi, Director, China Energy Research Institute
E. Linn Draper, Chairman, President and CEO, American Electric Power
Daniel Dudek, Senior Economist, Environmental Defense Fund
John H. Gibbons, Former Director, Office of Science and Technology Policy, Executive Office of the President
José Goldemberg, Former Environment Minister, Brazil
Jim Katzer, Strategic Planning and Programs Manager, ExxonMobil
Yoichi Kaya, Director, Research Institute of Innovative Technology for the Earth, Government of Japan
Hoesung Lee, President, Korean Council on Energy and Environment
Robert McNamara, Former President, World Bank
Hazel O'Leary, Former Secretary, US Department of Energy
Rajendra K. Pachauri, Director, Tata Energy Research Institute
Thomas Schelling, Distinguished University Professor of Economics, University of Maryland
Hans-Joachim Schellnhuber, Director, Potsdam Institute for Climate Impact Research
Kathryn Shanks, Vice President, Health, Safety and Environment, BP
Pryadarshi R. Shukla, Professor, Indian Institute of Management
Gerald Stokes, Assistant Laboratory Director, Pacific Northwest National Laboratory
John Weyant, Director, Stanford Energy Modeling Forum
Robert White, Former Director, National Academy of Engineering

Battelle
. . . Putting Technology To Work
901 D Street, S.W., Suite 900
Washington, D.C. 20024-2115