Powerful Partnerships:

A Synthesis of a Report by the President's Committee of Advisors on Science and Technology

"Advanced energy technologies can help meet the challenges of economic development, national security, and environmental quality." President Bill Clinton, July 23, 1998

It is in our fundamental National interest to greatly strengthen international cooperation in energy innovation. The President's Committee of Advisors on Science and Technology (PCAST) concluded that continuing our current energy trajectory would be "problem plagued and potentially disastrous." Unless innovation to increase energy end-use efficiency and to improve energy supply technologies is both rapid and global, world energy demand is likely to soar in the next century to four times today's level, entailing higher consumer costs for energy, greater oil-import dependence, worse local and regional air pollution, more pronounced climate disruption from greenhouse gases, and bigger nuclear energy risks than today. And if the United States abdicates leadership in international cooperation on energy technology while others forge ahead, it will cost U.S. firms dearly in their share of the multi-hundred-billion-dollar-per-year global market in energy-supply technologies, most of which is and will remain overseas. As the world heads into the next millennium, however, there is a window of opportunity — open now but closing fast — to move the world off this troublesome path. The choices the United States makes today will influence the evolution of the global energy system for many decades to come (Box 1). The United States has strong stakes in the future economic, national security, and environmental course of world energy development. (See references 1,2.)

Initiatives are recommended in four areas:

- **Strengthening capacities for energy technology innovation** through education and training; creation and support of regional centers for energy research and deployment; promotion of energy sector reform that attracts private capital while protecting the public interest; and creation of mechanisms for demonstration, cost-reduction and financing of advanced energy technologies;
- **Promoting technologies to limit energy demand** by increasing efficiency of energy use, particularly in buildings and appliances, small vehicles and buses, energy-intensive industries, and cogeneration of electricity;
- **Promoting technologies for a cleaner energy supply**, with emphasis on biomass, wind, solar, and other renewable energy sources, using fossil fuels far more efficiently, developing technologies to capture and store carbon, and nuclear fission and fusion; and
- **Improving management** of the Federal portfolio, including with external oversight.

These programs go beyond spurring research and development; they are designed to catalyze and facilitate efforts of the private sector, and will launch advanced energy technologies into substantial international markets, free of the need for ongoing government subsidies.

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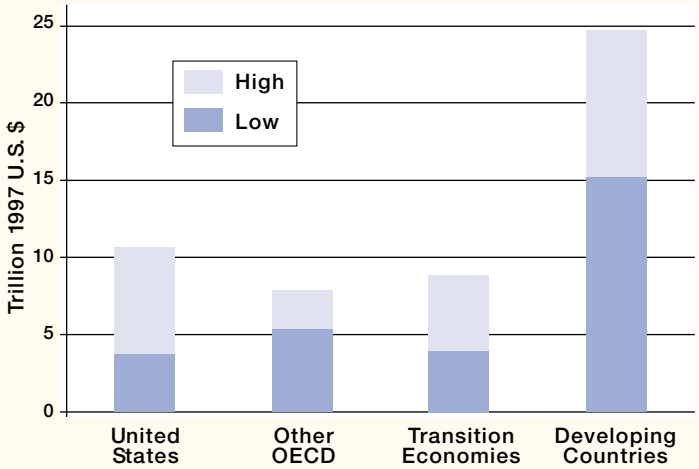
Energy use will grow dramatically worldwide—particularly in developing nations. Most of the twenty-fold world energy growth since 1850 has occurred in the industrial countries, and fossil fuels account for 78 percent of the world's energy supply (Figure 2). In the next two decades, however, over half of global energy growth will be in the developing and transition economies as those nations improve their standard of living. This growth will reduce the disparities in present per capita energy use (Figure 3) and improve well-being for the poorer inhabitants of the planet, but this rapid growth in total world energy use could further exacerbate the energy-linked problems and challenges already of great concern today.

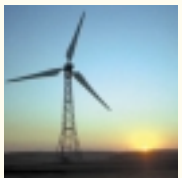
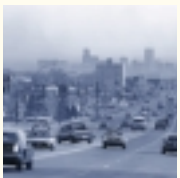
Technological innovation and the policies adopted to promote efficient and clean energy technologies will determine the quantity of energy used in the future and the impact of that energy use. An energy future that continues recent trends, including heavy reliance on conventional fossil fuel technologies, would commit the world to increased smog, acid rain, and other conventional air pollution problems, as well as the risk of climate change from increasing atmospheric carbon dioxide, approaching levels not seen on the planet for millions of years. Vigorous deployment of energy efficiency technologies, on the other hand, would mean the difference between doubling and quadrupling world energy supply by 2100 — a quantity of energy equal to the current oil output of nearly 50 Saudi Arabias — reducing the economic and national security consequences of such massive growth. Use of clean fossil, nuclear and renewable energy technologies means avoiding many of the environmental impacts looming in the coming century (Figure 2).

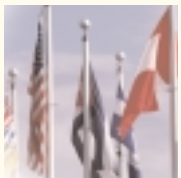
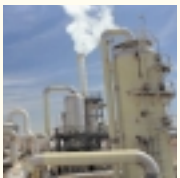
A significant portion of the demand for new energy technologies will be outside of the United States under any future scenario. Between now and 2050, investments in new energy technologies in developing nations will likely approach $15 to $25 trillion dollars, accounting for more than half of the global investments in energy supply (Figure 1). Ninety percent of the markets for coal, nuclear, and renewable energy technologies are expected to be outside of the United States in the coming decades. Strategic investments today — by the U.S. government and the private sector — will assist strong participation in those markets tomorrow.

Figure 1: Projected Total Investment in Energy-Supply



Future investments in energy supply technologies will be much larger outside the United States. Developing countries will account for the largest share—roughly $15-25 trillion from 1990-2050. Energy efficiency investments will be of similar magnitude as countries develop their buildings, industry, and transport infrastructures. Adapted from (3).

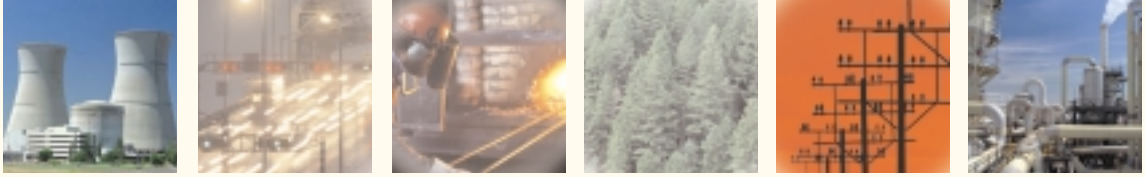
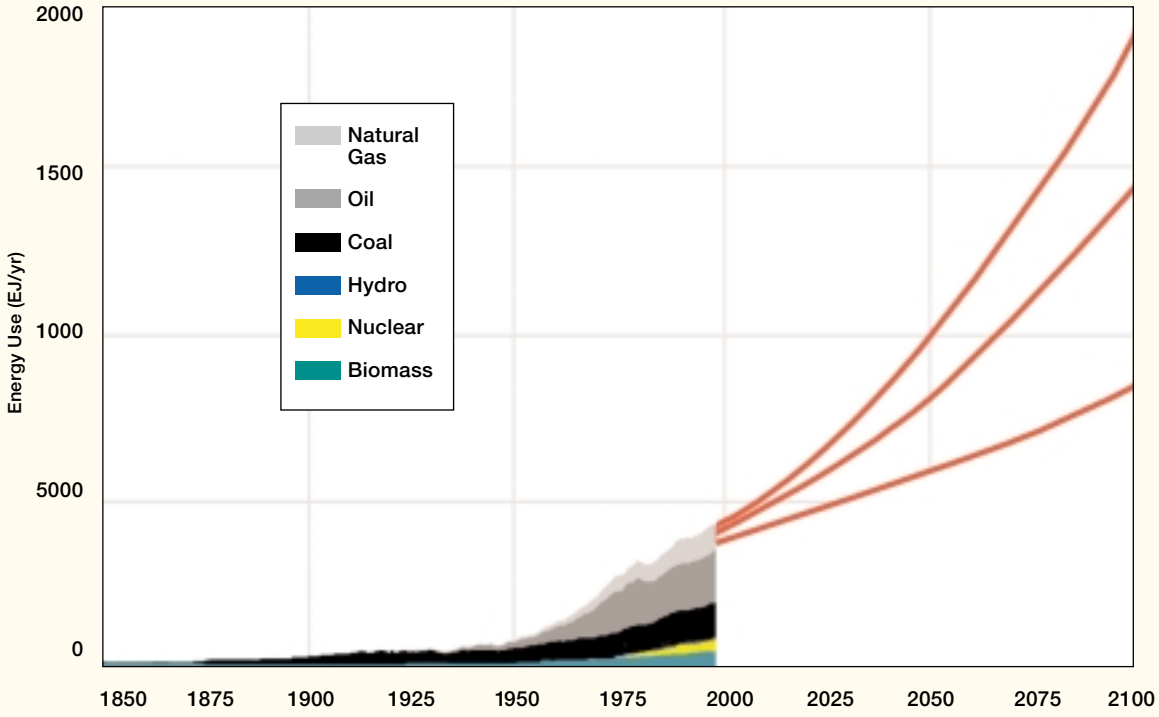


Figure 2: Historical and Projected Energy Use



World energy use is growing rapidly and is dominated by fossil fuels. The future path depends on economic growth, technological change, and investments in energy efficiency. 1Exajoule = 0.95 Quad = 160 million barrels of oil. Adapted from (3).

Box 1: Global Energy Challenges and the U.S. National Interest

- *Economic:* International cooperation provides economic opportunities for U.S. companies to access global energy supply technology markets, worth hundreds of billions of dollars each year. Action now can give U.S. companies access to the best innovative ideas in the world and open doors to these markets, the bulk of which will be outside of the United States in the coming century (Figure 1). Such innovation will also lower the cost of energy for U.S. consumers.
- *National Security:* New technology to power vehicles with greater efficiency or with alternative fuels reduces domestic and international dependence on oil supplies from politically volatile regions. Advanced reactor designs can potentially reduce nuclear proliferation risks. Clean energy supplies for economic development enhance the political and economic stability needed for sound markets and international trade.
- *Environmental:* Clean, low-carbon sources of energy—renewable, advanced fossil, and nuclear—together with energy-efficient cars, buildings, and industries, can reduce air pollution and greenhouse gas emissions and nuclear reactor waste and safety concerns domestically and internationally. It can also help create a framework for wider cooperation on the energy climate challenge in which developing, transition, and industrialized countries alike will participate.

References:

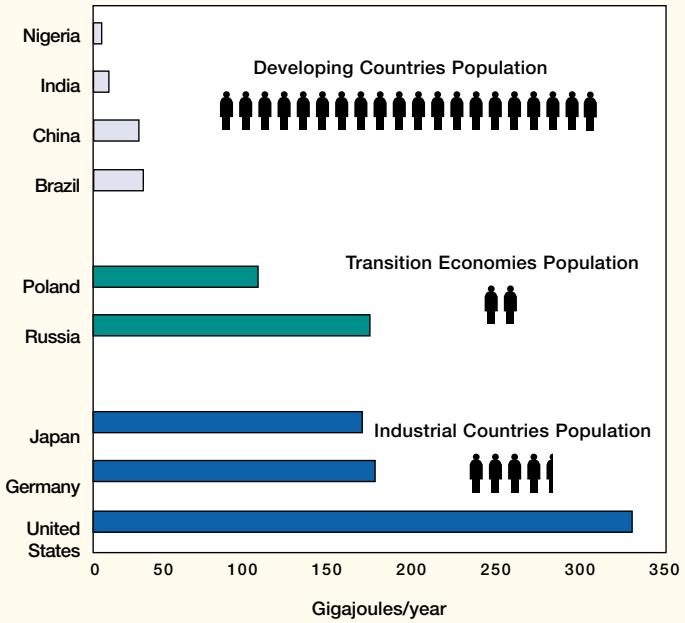
1. President's Committee of Advisors on Science and Technology, Panel on Energy Research and Development, *Federal Energy Research and Development for the Challenges of the Twenty-First Century,* (Washington, DC: Office of Science and Technology Policy, November 1997), http://www.whitehouse.gov/WH/EOP/OSTP/html/OSTP_Home.html
2. President's Committee of Advisors on Science and Technology, Panel on International Cooperation in Energy Research, Development, Demonstration, and Deployment, *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation,* (Washington, DC: Office of Science and Technology Policy, June 1999), http://www.whitehouse.gov/WH/EOP/OSTP/html/OSTP_Home.html
3. N. Nakićenović, A. Grübler, and A. MacDonald, eds., *Global Energy Perspectives* (Cambridge, UK: Cambridge University Press, 1998).
4. World Bank, *World Development Report 1998/99: Knowledge for Development*, (New York, NY: Oxford University Press, 1999).

The cover photo shows electric lights on earth at night, adapted from satellite imagery. Courtesy of NASA.

Box 2: The Window of Opportunity

- *Energy-sector restructuring and regulatory reform* in many countries will be largely completed over the next decade and will "lock in" the mechanisms determining success or failure in the dual aims of attracting private capital and addressing public benefits.
- *Rapid urbanization* will "lock in" land-use patterns and infrastructure — including the configuration of urban transportation networks, patterns of urban sprawl, and building design — for a century or more.
- *Investments in energy research, development, demonstration, and deployment made today* will influence the characteristics of the world energy system for many decades. Many energy technologies deployed between now and 2020 will still be in operation in 2050. Investments made today in research and development will determine the new technologies available for deployment between 2020 and 2050. Thus, today's choices will strongly influence energy costs, greenhouse gas emissions, oil dependence, proliferation resistance, and public-health impacts for the balance of the next century.

Figure 3: Per Capita Energy Use and Population



Current per capita energy use shown for selected countries and total population in developing countries, reforming economies, and OECD countries. (Excludes traditional biomass.) One = 200 million people. 1 Gigajoule = 0.95 million Btus = 7 gallons of gasoline. Data drawn from (4).

Government has a critical and legitimate role to play. The private sector plays the major role in energy innovation and related international cooperation. Private-sector investments alone, however, will not adequately capture the full range of public benefits — like reduced pollution, increased energy security, long-term technology innovation, and developmental equity issues. Government activities focused on filling the gaps in private-sector investment can achieve significant benefits for the United States.

Current government programs cannot meet the challenges of future global energy growth. In 1997, government expenditures on international cooperation on energy innovation amounted to about $250 million per year, but these funds were primarily in nuclear fission and fusion. The government has few programs to bridge the gap between R&D and commercial deployment The lack of government programs for the middle part of the technology innovation "pipeline" — demonstration and early deployment — impedes the commercialization of innovative energy technologies (Figure 4). To address the full spectrum of energy technology needs, PCAST recommends doubling the present funding for federal programs in international energy cooperation in FY 2001, focusing on programs that build stronger foundations for energy technology innovation, promote innovation in energy end-use, and promote clean and efficient energy supply. (See Table 1.)

Strengthening North-South cooperation on clean and advanced energy technologies is a promising approach to helping secure developing country participation in an international framework for addressing global climate change. The United Nations Framework Convention on Climate Change — signed by President Bush and ratified by the U.S. Senate — calls explicitly for such cooperation. This cooperation would help provide the alliances, information, and foundations needed to achieve specific developing nation commitments to greenhouse gas emissions-reductions targets and timetables.

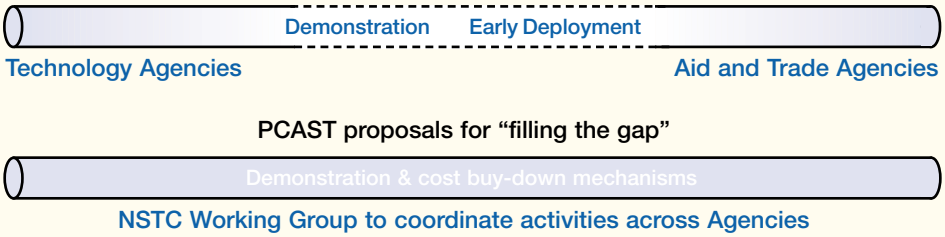
Greater cooperation with other industrial countries can help build the scientific and technological basis for more rapid innovation in the energy sector. Industrial country cooperation can also play a key role in developing the competitive mechanisms needed to bridge the gap in the innovation pipeline (Figure 4) for technologies with significant public benefits.

A unified vision and coordinated management structure will enhance U.S. international cooperative efforts on energy. PCAST calls for a new Interagency Working Group on Strategic Energy Cooperation under the National Science and Technology Council, to provide overall coordination and assess agency programs. The Working Group should have an Advisory Board drawn from the private, academic, and NGO sectors. PCAST recommends that the Working Group conduct portfolio assessments to help oversee development of a coordinated Strategic Energy Cooperation Fund, designed to promote and support programs in international energy cooperation.

The Panel concluded:

> "The needs and opportunities for enhanced international cooperation on energy-technology innovation supportive of U.S. interests and values are thus both large and urgent. The costs and risks are modest in relation to the potential gains. Now is the time for the United States to take the sensible and affordable steps outlined here to address the international dimensions of the energy challenges to U.S. interests and values that the 21st century will present."

Figure 4: The "technology innovation" pipeline today, with primary Agency supports



The innovation pipeline for energy technology has a significant gap between government programs for R&D and government programs to support successful commercialization. This gap constrains the deployment of innovative technologies. To bridge that gap, PCAST recommends mechanisms for demonstrating technologies, competitively buying-down their price, and for coordinating the work of the technology development, aid, and trade agencies. Agencies involved include the Departments of Commerce, Energy, and State, the United States Agency for International Development, the Environmental Protection Agency, Export-Import Bank, Overseas Private Investment Corporation, and the Trade and Development Agency, among others.

This study responds to President Clinton's request to identify "ways to improve the U.S. program of international cooperation on energy R&D to best support our nation's priorities and address the key global energy and environmental challenges of the next century". A PCAST Panel investigated these issues intensively for 9 months and wrote a comprehensive report. This Panel included fourteen experts drawn from a diverse mix of industry, academic, non-governmental and other organizations, and with a wide variety of backgrounds and perspectives. Despite this diversity, these members were unanimous in making the recommendations in this report, noting that there is a narrow window of opportunity for the United States to respond to the urgent needs they identified (Box 2). The full PCAST has also endorsed this report. The PCAST serves as the highest level private sector science and technology advisory group for the President and the National Science and Technology Council.

The PCAST Panel on International Cooperation in Energy Research, Development, Demonstration, and Deployment

John P. Holdren
Harvard University
PCAST Member
(Panel Chair)

Richard Balzhiser
Electric Power Research Institute

John P. Boright
National Research Council

William Chandler
Battelle Pacific Northwest National Laboratory

John M. Deutch
Massachusetts Institute of Technology
PCAST Member

Howard Geller
American Council for an Energy Efficient Economy

John H. Gibbons
Assistant to the President for Science and Technology, ret.

Larry T. Papay
Bechtel Group, Inc.

Nathan Rosenberg
Stanford University

Maxine Savitz
Allied Signal Ceramic Components

Bruce N. Stram
Enron Energy Services

Robert Williams
Princeton University

Lilian Shiao-Yen Wu
IBM
PCAST Member

John A. Young
Hewlett-Packard Co.
PCAST Co-Chair

Study Executive Director
Samuel F. Baldwin
National Science and Technology Council

Assistant to the Chair
Paul de Sa
Harvard University

Initiatives and Budgets (Budgets in Millions of $ Supplemental Spending)

FOUNDATIONS OF ENERGY INNOVATION		FY2001	FY2005
Capacity Building	Increase the capacity for energy innovation by investing in education and training programs and supporting regional centers for energy research, development, demonstration, and deployment.	$20M	$40M
Energy Sector Reform	Provide assistance for energy-sector reform that attracts private investment and includes mechanisms to protect the public's interest in energy innovation that reduces environmental impacts, addresses the energy needs of society's poorest members, and provides other societal benefits not captured in markets. Provide assistance in establishing regulatory frameworks for natural gas grids.	20	40
Demonstration and Cost Reduction	Establish an international Demonstration Support Facility to promote pre-commercial, private-sector-sponsored demonstrations of clean and efficient energy technologies. Allow energy-production tax credits for U.S. firms participating in demonstration projects abroad. Promote market-based mechanisms to reduce the difference in cost between advanced and conventional energy technologies by means of the learning that accompanies increased production.	40	80
Financing	Encourage the World Bank and other multilateral development banks to increase financing for clean and efficient energy technologies; provide trust funds to the banks for analytical and assessment activities in support of such lending. Facilitate market-based finance of these technologies by creating a fund administered by the Overseas Private Investment Corporation to mitigate financing risks in private and joint public-private projects of this type abroad.	40	80
A PORTFOLIO OF ENERGY EFFICIENCY RESEARCH, DEVELOPMENT, DEMONSTRATION AND DEPLOYMENT			
Buildings	Reduce energy use of new buildings in developing and transition economies by 50% by 2020 by assisting them to develop efficiency standards, ratings, and labeling for building equipment as well as design tools, energy codes, and standards for building shells. Encourage multilateral development banks and the Global Environment Facility to support such measures.	20	40
Transport	Expand research, development, demonstration, and cost-reduction efforts to achieve inexpensive, efficient, and clean small vehicles and buses. Assist in analysis and implementation of vehicle emissions testing and standards. Engage the multilateral development banks and the Global Environment Facility in support of these measures.	20	40
Industry	Invent the factories of the 21st century through U.S. public/private/foreign partnerships to develop and implement energy-efficient technology roadmaps for energy-intensive industries.	10	20
Combined Heat and Power (CHP)	Maximize CHP's (cogeneration's) share of the market for new power generation in developing countries through collaborative assessments of potential CHP sites, addressing regulatory/market barriers, attracting funding for demonstrations, helping secure financing, and through information and training programs.	10	20
A PORTFOLIO OF ENERGY SUPPLY RESEARCH, DEVELOPMENT, DEMONSTRATION AND DEPLOYMENT			
Renewables	Achieve widespread use of renewables, comparable to fossil fuel use today, by 2025-2050. Conduct research, development, demonstration, and cost-reduction efforts on industrial-scale use of biomass to generate power and coproducts and on integrated renewable energy and hybrid systems for use in rural areas. Accelerate deployment of grid-connected intermittent renewable/hybrid systems.	40	80
Fossil Fuel	Develop economic fossil fuel decarbonization and carbon-storage technologies with near-zero carbon and pollutant emissions, including low-cost hydrogen production and byproduct carbon recovery. Evaluate carbon-reservoir potential.	20	40
Nuclear Energy	Preserve nuclear energy as a 21st century option by expanding the Nuclear Energy Research Initiative with increased international cooperation addressing cost, safety, waste, and proliferation issues for nuclear fission. Increase international cooperation on spent-fuel management and high-level wastes. Pursue new international agreement on fusion R&D.	10	20
A SET OF MANAGEMENT RECOMMENDATIONS			
Agency Management	Establish an interagency working group under the National Science and Technology Council, with an external Advisory Board, to provide strategic vision, interagency coordination, portfolio analysis, and strengthened evaluation. Agencies would use competitive solicitations to identify best approaches. Strengthen agency international capabilities.		
TOTAL	**Strategic Energy Cooperation Fund**	$250M	$500M

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Telephone: 202-456-6100 / Facsimile: 202-456-6026

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