Hearing on
Science of Climate Change
Committee on Energy and Natural Resources
U.S. Senate
28 June 2001

Testimony of
William Chandler
Senior Staff Scientist and Director, Advanced International Studies Unit
Pacific Northwest National Laboratory

The U.S. Stake in International Cooperation on Energy Innovation

This testimony summarizes the conclusions of *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation*, a 1999 report to the President by the President's Committee of Advisors on Science and Technology (PCAST).[1] The authors of this report, the PCAST International Energy Panel, concluded that U.S. self interest would be served

International Energy Challenges

Economic
- Growth and development
- Energy technology exports
- Oil Imports

Environmental
- Local air quality
- Regional acid rain
- Global warming

U.S. Leadership
- Energy Science
- Supply- and demand-side technology

International Security
- Insecure supplies of foreign oil
- Nuclear proliferation
- Political stability in developing countries

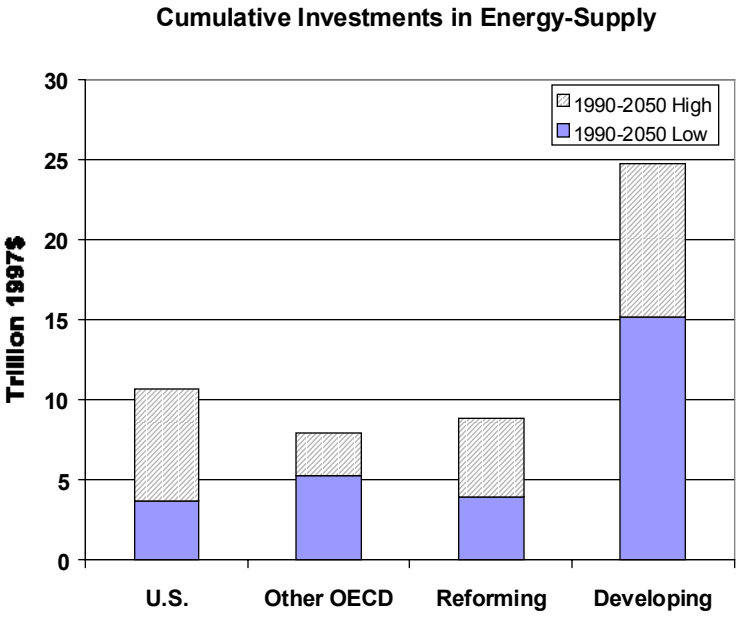
U.S. Values
- Human rights
- Civil society
- Equity, self-determination, stewardship.

U.S. President's Committee of Advisors on Science and Technology, *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation* (Washington, D.C.: The White House Office of Science and Technology Policy, June 1999). Available at **http://www.ostp.gov/html/P2E.pdf.**

by increasing international energy cooperation, particularly with the transition and developing economies where most energy demand growth will occur this century. Our panel found that

global energy use is tightly linked to U.S. economic, environmental, and national-security interests (see box, above). We concluded that energy technology innovation improves our security, helps the United States avoid inflation and recession, and expands our market share of multi-hundred-billion dollar per year global energy-technology market. Significantly, energy innovation can help mitigate greenhouse gas emissions in the fastest-growing energy demand markets.

The United States and the world face a historic window of opportunity. The largest investments in energy supply and conversion systems will occur in developing and reforming countries, and these will soon "lock in" technologies for decades to come (see figure). The long lead-time required to move new technologies through the innovation pipeline–let alone penetrate markets–means that efforts to deploy technology in the second quarter of this century need to be started today. PCAST proposed early but modest funding for international cooperation, with specific suggestions for budget increases amounting to $500 million per year by FY2005.



PCAST found that great leverage for greenhouse gas emissions reductions comes with supporting market-based policy reform and in organizing financing to implement energy technology transfer in developing and transition economies. Economic reform—getting prices right and making prices matter—can help reduce emissions in countries as diverse as Brazil, India, China, India, Russia, and Ukraine by reducing distortions and subsidies that encourage energy waste. Efforts to organize investment financing for energy innovation can multiply the effectiveness of government funds.

Priority Initiatives

The PCAST International Energy Panel reviewed both successes and failures in international energy development and agreed to recommend four categories of initiatives for top priority, including capacity building for reform and innovation, deployment of energy-efficiency

PCAST Initiatives for International Energy Cooperation

Foundations of Energy Innovation
- Capacity Building
- Energy Sector Reform
- Finance

Energy Efficiency Portfolio
- Buildings
- Transport
- Industry
- Combined Heat and Power

Energy Supply Portfolio
- Renewables
- Fossil fuel
- Nuclear energy

Management Recommendations
- National Science and Technology Council working group
- External Advisory Board

Source: *Powerful Partnerships*, President's Committee of Advisors on Science and Technology, 1999. Available on-line at http://www.ostp.gov/html/P2E.pdf

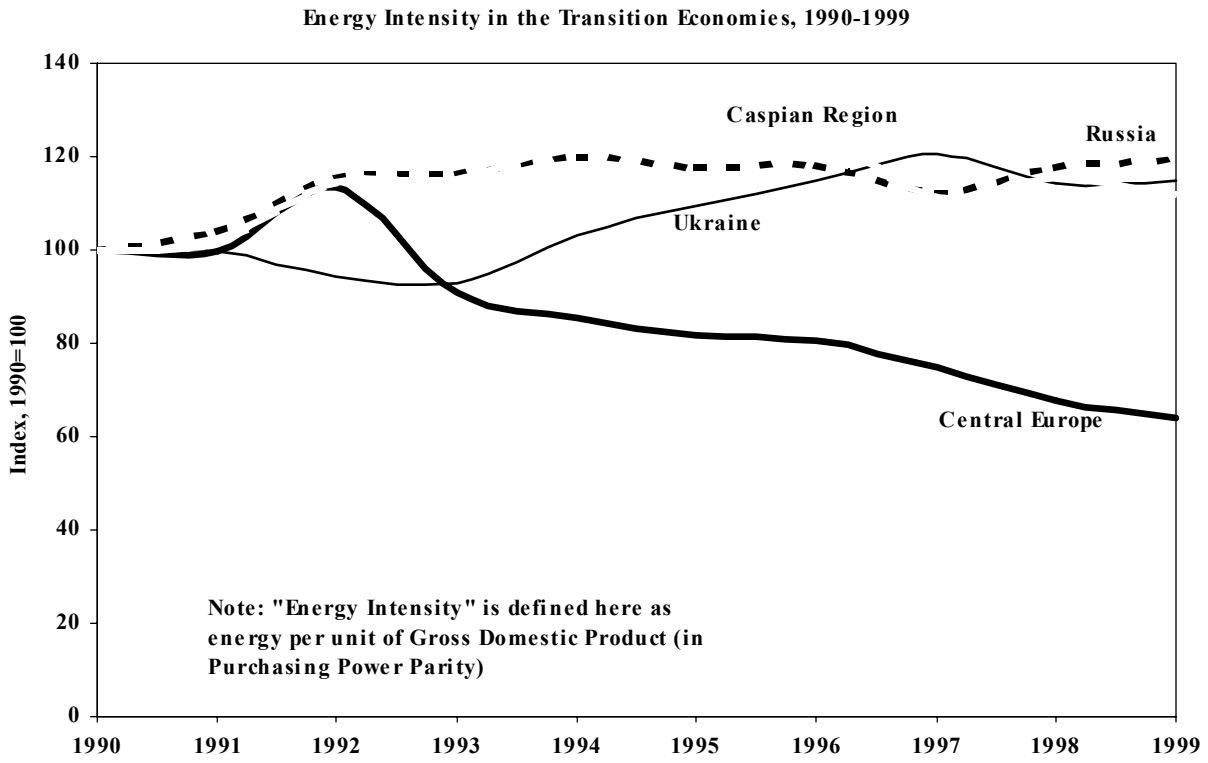
technologies, deployment of selected supply-side technologies, and management reform (see box).[1]

PCAST members were struck by the degree to which "reform matters," and by successful interventions by the U.S. government which have helped to support energy sector reform. The experience of Central Europe is instructive in this regard. Energy intensity serves as an index of reform, as an indicator of successful and unsuccessful policies. Central Europe has cut energy intensity by one third over the last decade, with major benefits for both the economy and environment of that region, and demonstrating that genuine reform works (see figure, below). Essentially, this means that the region has eliminated much of the energy waste that stemmed from the legacy of central planning. Poland, the Czech Republic, and Hungary achieved this success by implementing hard budget constraints, meaningful energy prices, institutional reform, and economic restructuring. Latin American nations, including Argentina, have also benefitted by embracing privatization and competition.[2] Nations failing to implement those measures elsewhere robbed citizens of economic and social well-being.

Foundations of Energy Innovation

Efforts to build the foundations of energy-sector innovation include measures to enhance management and technical capacity, reform of the energy-sector, and organizing financing for innovative investment. U.S. funds helped organize over $1 billion of energy-efficiency

1. This testimony emphasizes the "foundations" and energy efficiency recommendations by the PCAST panel.



Note: Central Europe includes Bulgaria, Czech Republic, Hungary, Poland, Romania, and Slovakia; Caspian Region includes Azerbaijan, Kazakstan, Turkmenistan, and Uzbekistan.

Source: Author; *CO_2 Emissions From Fuel Combustion, 1999 Edition* (Paris: International Energy Agency, 1999), p. II.27; *World Economic Outlook 2000* (Washington: International Monetary Fund, 2000), p. 123; and BP Amoco, *Statistical Review of World Energy 2000*, www.BPAmoco.com.

investment projects in this region over the past five years and has built non-governmental, not-for-profit organizations in Russia, Ukraine, Bulgaria, Poland, and the Czech Republic. These organizations have developed world-class expertise each with staffs of 15-50 people. Each center is now self-sustaining and fully independent. U.S. partners associated with the program have been honored with the "Global Climate Leadership Award" (International Energy Agency) and with the "International Energy Project of the Year Award" (Association of Energy Engineers) for this work. U.S. expenditures on these assistance programs through resulted in investment 25-50 times the initial grant. PCAST have reported on these and similar successes in Latin America, especially in Brazil.

China offers a remarkable success story in managing energy demand growth. China suffers severe environmental problems due to distorted markets, outdated technologies, and inefficient management. The World Bank estimates that approximately eight percent of the country's gross domestic product is lost each year due to pollution that damages human health, natural

ecosystems, and physical infrastructure. Fortunately, China has made progress with energy efficiency having probably reduced current levels of greenhouse gas emissions by one-third or more.[3] China's post-reform economy has grown faster than energy use for more than two decades. China continues to rank energy efficiency as vital to the nation's energy interests. Domestic reforms within China have the potential further to cut carbon dioxide emissions significantly, as does cooperation with international partners.

The U.S. government has successfully collaborated with Chinese researchers for over a decade on China's energy and environmental problems working with some of China's leading energy and environmental specialists. In 1993, the Department of Energy and the Environmental Protection Agency (in collaboration with Pacific Northwest National Laboratory and Lawrence Berkeley National Laboratory) helped establish the Beijing Energy Efficiency Center (BECon) with support from the American and Chinese governments and the World Wide Fund for Nature. Chinese researchers have collaborated with U.S. experts to demonstrate that China could meet its future electric power needs at a lower overall cost if environmental factors where included in the planning process.[4] Ongoing Sino-U.S. collaboration on energy efficiency helps to catalyze additional measures to improve energy efficiency, reduce pollution, and boost exports of U.S. technology.[5]

Capacity-building efforts prepare the ground for rapid and sustainable energy-technology innovation. As indicated in the PCAST report executive summary, high-priority elements include:

- Increased support for existing regional centers of analysis and information dissemination on sustainable energy options (such as the PROCEL national electricity-conservation program in Brazil, energy efficiency centers in Eastern Europe and Russia,[6] and other centers in Africa, Asia, and Latin America) and establishment of new sustainable energy centers in regions with significant need that cannot be met by other means; and

- Development of in-country training for energy analysts and managers, to include workshops and internet-based courses and expert assistance, as well as a requirement that in-country technical and managerial training be a component of technology demonstration and deployment projects supported by the U.S. government.

Supporting and shaping energy-sector reform accelerates financial performance and helps retain incentives for energy-technology innovation. The U.S. government can mobilize private and public sector experts to provide technical and policy advice, particularly for price reform and imposition of "hard budget constraints". For example, one way the United States can help promote the use of low-carbon natural gas in China is by analyzing current obstacles and then promoting the needed legal framework for building and regulating natural gas supply pipelines and distribution systems (see box).[7]

A large payoff comes especially by helping provide the conditions sufficient to attract international investors. Lack of credit, collateral, or funds to prepare business plans are the biggest barriers to energy efficiency and fuel switching in many economies. Financial programs can help overcome barriers to deployment of small-scale clean and efficient energy technologies in transition and developing economies. High-priority elements include increasing support for clean and efficient energy technologies from the multilateral banks or through U.S. mechanisms such as the Trade Development Agency and the Development Credit Authority. European nations are often much more pro-active in supporting multilateral banks in project planning work that would overcome barriers to obtaining financing and, as a result, often increase their market share of these developing markets.

What U.S. Companies Say They Need to Do Natural Gas Business in China

1. Boost gas prices to international market levels.
2. Expand use of gas to industry and power sectors.
3. Allow access to choice areas for exploration.
4. Develop greater market transparency.
5. Improve data accessibility.

Source: Logan, J. and W. Chandler, "Incentives Needed for Foreign Participation in China's Natural Gas Sector." *Oil and Gas Journal*, 10 August 1998. Volume 96, Number, 32. p. 50-56.

"Financial engineering" is the best lever for emissions reduction because it transfers energy-efficient modern technologies through the marketplace. Specifically, the U.S. government can provide funding to identify customers for energy-saving equipment, develop business plans to move projects through the inception stage, and identify private and multi-lateral sources of finance to implement projects. An appropriate goal is to leverage at least $25 of investment for each dollar spent by the U.S. government in project development.

Portfolio of Energy End-Use Technologies

PCAST's second category of initiatives addresses specific opportunities for international cooperation to promote innovation in energy-end-use technologies. These include efforts to reduce the energy intensity of heavy industry in key developing and transition countries. The PCAST panel estimated that energy use per unit of industrial output could be reduced by 40 percent over the next two decades. A successful example of this type of approach includes a dozen factories in Ukraine—a very difficult financial environment—which recently arranged millions of dollars of private investment in energy efficiency measures thanks largely to U.S. government support. Actual energy savings averaged 20 percent of total energy use per plant.[8]

The United States could encourage developing countries to cut energy use in major energy-

intensive industrial processes by one-third or more compared to current performance. The largest energy-consuming sectors include iron and steel, cement, chemicals, pulp and paper, and non-ferrous metals. The Chinese steel industry, for example, uses 90 percent more energy to make a ton of steel than the Japanese steel sector. Similarly, India uses twice as much energy to make a ton of pulp and paper than the OECD average. Russian cement makers use 30 percent more energy to manufacture a ton of cement than French manufacturers. American technologies could be applied to cut energy use in each of these cases. However, these technologies have not penetrated these markets due to price distortions, lack of trained personnel to develop and implement projects, and lack of business skills and credit to arrange financing to make projects reality.

High-priority efforts toward that goal could include cooperation with the private sector and foreign counterparts to develop "technology roadmaps" and pre-competitive research and development for energy-intensive basic-materials industries such as iron and steel, chemicals, pulp and paper, and cement. Pilot demonstration programs and joint project development can sometimes facilitate technology transfer between U.S. firms and their partners.

PCAST's set of end-use recommendations included cooperation on vehicles research, development, and demonstration of cleaner, more energy-efficient buses and two- and three-wheeled vehicles (the main source of individual transport in many Asian nations) and accelerating deployment of advanced vehicles in developing and transition countries. High-priority efforts might include integration and expansion of cooperative research and development, especially for hybrid, fuel-cell, and alternative-fuel propulsion systems. U.S. encouragement of the multilateral development banks to help finance energy-efficient vehicle-manufacturing capacity, infrastructure, and consumer-credit systems could speed large-scale deployment of these advanced vehicles.

International Role of Energy-efficiency Technology

- Efficiency aids development and cuts emissions.
- Transition (and some developing) economies rank least-efficient in the world.
- Investment and reforms promote efficiency and fuel switching.

PCAST recommended buildings sector demand-side energy cooperation. The U.S. government could help transition and developing countries cut energy use in new appliances, homes, and commercial buildings in developing countries by 25 percent compared to current practice. Developing countries continue to build homes with energy-intensive materials that have low thermal-insulation values. Buildings-energy use can be cut by one-third or more with advanced design techniques available in the United States.

High-priority efforts could include technical and policy assistance for efficiency standards and ratings and labeling of building equipment and appliances. PCAST supported the idea of U.S. sponsorship of labeling and promotion programs similar to the "Energy Star"; design competitions to push the envelope of building energy performance; and technical assistance for development, analysis, and implementation of building energy codes and standards, including use of monitoring, compliance, enforcement programs, and software.

PCAST end-use experts recommended efforts to promote combined-heat-and-power, or cogeneration, technologies for new power supply. Countries with rapidly growing power demand such as China, India, and much of Latin America could obtain one-fifth of their new power supply from cogeneration or distributed power systems using microturbines, renewable energy, and other new power generation systems.

Enron Corporation's frustrating experience in building and operating a power plant in Dabhol, India, is well known. That experience, and others like it around the world, have shown that regulatory reform in developing nations is badly needed.[9] Assistance by U.S. experts to "level the playing field" for modern generating technologies, especially cogeneration, can help create functioning markets and facilitate penetration of advanced technologies in countries like India. PCAST determined that successful deployment of cogeneration will required five things: information and education programs; collaborative assessments of power and heat loads at potential cogeneration sites; addressing potential regulatory and market barriers; funding for demonstrations; and help in securing financing.

Funding for market surveys of potential cogeneration sites would help to determine power and heat loads and output ratios in order to identify favorable conditions. Such an effort would also need to identify and suggest solutions to regulatory barriers such as difficulties selling power to the grid. Technical and policy assistance could help develop and implement policies that are equitable for cogeneration. This activity, like the industrial initiative above, could also leverage funding for innovative demonstrations of combined heat and power and to help secure financing from international private and public sources.

Portfolio of Supply-Side Projects

PCAST noted that specific opportunities exist for international cooperation for innovation on energy-supply technologies to help spread use of technologies for renewable energy, fossil-fuel decarbonization, carbon dioxide sequestration, and nuclear fission and fusion. Priority was placed on accelerating the development and deployment of biomass, wind, photovoltaic, solar thermal, and other renewable energy technologies. Also needed are collaborative research on restoring degraded lands, and developing fossil-energy hybrids to provide complete energy services for agricultural, residential, and village-scale commercial and industrial applications in rural areas.

Among the supply-side options considered, PCAST emphasized the need for collaboration to develop industrial-scale biomass energy conversion technologies, as well as collaborative research on the restoration of degraded lands and their use for growing crops optimized to yield multiple products. PCAST found that collaboration is needed to accelerate the deployment of grid-connected intermittent renewable electric technologies with fossil energy. The panel further suggested then need for collaboration on assessments of renewable energy resources on a region-by-region basis.

PCAST found need to add an explicit international activity to promote research focused on advanced technologies for improving the cost, safety, waste management, and proliferation resistance of nuclear fission energy systems, and to expand and strengthen exchanges on geologic disposal of spent fuel and high-level wastes. Our panel recommended pursuit of a new international agreement on fusion research and development that commits parties to a broad range of collaborations on all aspects of fusion energy development to enhance U.S. participation in existing fusion experiments abroad and inviting increased foreign participation in new and continuing smaller fusion experiments in the United States.

Management Initiative

PCAST recommended that the President should establish an interagency working group on strategic energy cooperation in the National Science and Technology Council to develop and promote a strategic vision of the role of the government's contributions to international energy. This working group would be responsible for continuing assessment of the government's full portfolio and would assist the agencies to strengthen their internal and external mechanisms for monitoring and reviewing projects, for terminating unsuccessful ones, and for handing off successful ones to the private sector at the appropriate time.

PCAST stressed the role of the private sector. Government programs should be structured to catalyze and complement the private sector, not replace it. International programs should help lower barriers and supplement private incentives and capacity to address U.S. interests in energy innovation. But assistance should be limited in the rate and duration of the government's investment, with specific criteria for terminating projects that fall short and for transferring successful ones to the private sector.

PCAST concluded that government involvement is needed because the public interest in energy outcomes goes beyond the sum of perceived private interests. Privatization, deregulation, and restructuring of energy industries help bring private capital into the energy sector.

Fleeting Opportunities

International carbon dioxide emissions trading offers a potentially important tool for deploying technology to mitigate greenhouse gases, but that tool may be slipping from our grasp. Large-

scale, inexpensive emissions mitigation opportunities exist in the transition economies–Russia and Ukraine, for example–and a trading regime could provide the incentive for market adoption of technologies that will substantially reduce future emissions levels. But transition economies have encountered difficulty in organizing a transparent and effective trading system, a condition that may be worsened if U.S. policy suggest that we have abandoned our commitment to "flexible mechanisms"[10], as agreed in the Framework Convention on Climate Change. Much more serious cooperation with transition economies will be needed to encourage establishment of serious mechanism to deploy emissions-mitigating technologies.

The needs and opportunities for international energy cooperation are thus large and urgent. The costs and risks are modest in relation to the potential gains. Our best opportunities include helping build local leadership capacity, supporting energy-sector reform, and helping finance the market penetration of energy-efficient and environmentally benign energy technologies. Shifting to this brand of international energy cooperation, the panel found, would provide more benefit to American security, trade, and its environment than the general approach to technical assistance.

Policy-makers might find encouragement and challenge in these ideas. Concerns that climate and environmental protection policy would lead to greater, not less, command and control appear exaggerated. The literature suggests that transition to markets and competition will actually help cut emissions growth, at least up to a point. Concern that cutting emissions growth in developing countries would cost impossible sums and retard economic development also appears misplaced. But confidence that markets will readily work and that technology will eventually solve the carbon emissions problem seem naive. Markets remain distorted, fuel and capital are wasted on a large scale, and opportunities for efficiency and environmental protection are squandered. Most developing and transition economies lack the tax, regulatory, and incentive programs to address the energy and climate challenge. Markets will not alone create the advanced technology necessary to even approach the goal of the United Nations Framework on Climate Change–stabilizing concentrations of greenhouse gases. The magnitude of change required is such that only some significant shift in markets—such as an agreement to limit emissions per unit of energy produced, or a functioning emissions trading system—would make meaningful change achievable.

International Energy Panel,
President's Committee of Advisors on Science and Technology,
1999

- John P. Holdren, Professor of Environmental Policy, Harvard University, (Chair)
- Richard Balzhiser, President Emeritus, Electric Power Research Institute
- John Boright, Executive Director, Office of International Affairs, NRC
- Bill Chandler, Director, Advanced International Studies, PNNL
- John Deutch, Institute Professor of Chemistry, MIT
- Howard Geller, Executive Director, ACEEE
- John H. Gibbons, Former Science and Technology Advisor to the President
- Larry Papay, Senior Vice President for Research, Bechtel Corporation
- Nathan Rosenberg, Professor of Economics, Stanford University
- Maxine Savitz, General Manager, Allied Signal Ceramic Components
- Bruce Stram, Vice President, Business Development, Enron Energy Services
- Bob Williams, Senior Scientist, Energy & Environmental Studies, Princeton
- Lilian Shiao-yen Wu, Research Scientist, IBM
- John Young, PCAST Co-Chair and former CEO, Hewlett-Packard Corp.

- Sam Baldwin, Study Director, OSTP
- Paul de Sa, Assistant to the Chair, Harvard
- Ann Kinzig, Roger Revelle Fellow, OSTP
- Martin Offutt, OSTP

Notes and Sources

1. U.S. President's Committee of Advisors on Science and Technology, *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation* (Washington, D.C.: The White House Office of Science and Technology Policy, June 1999). Available at **http://www.ostp.gov/html/P2E.pdf.** The author of this testimony participated as a panelist and author in this PCAST study.

2. William Chandler, *Energy and Environment in the Transition Economies* (Boulder: Westview Press, 2000).

3. Over the past twenty years, China's energy consumption per unit of growth in gross domestic product measured in constant local currency has declined by over 4 percent annually, while energy consumption per unit of growth in the U.S. has fallen by slightly over 1 percent. Typical developing countries, on the other hand, exhibit an increase in energy consumption related to economic growth. See *Climate Action in China and the United States*, Battelle Memorial Institute and the Woodrow Wilson Center for International Scholars, Washington, DC, 1999. Official Chinese statistics on economic growth are viewed from abroad with increasing skepticism, however, and real growth may be significantly less than reported. A forthcoming report from Lawrence Berkeley National Laboratory provides a more realistic estimate of China's success in conserving energy based on revised economic growth estimates. See Sinton, J., and D. Fridley, "What Goes Up: Recent Trends in China's Energy Consumption," Forthcoming in *Energy Policy*.

4. See, "Electric Power in Five Developing Countries: The Futures of China, Korea, India, Argentina, and Brazil," William Chandler, Battelle Memorial Institute, for the Pew Center on Climate, forthcoming 2001.

5. A website on energy efficiency news in China reaches 5,000 readers each month from all over the world.

6. The author led the creation of six institutions of local expertise, including energy-efficiency centers in Bulgaria, China, the Czech Republic, Poland, Russia, and Ukraine. See William U. Chandler, John W. Parker, Igor Bashmakov, Zdravko Genchev, Jaroslav Marousek, Slawomir Pasierb, Mykola Raptsun, and Zhou Dadi, "Energy Efficiency Centers in Six Countries: A Review," November 1999, PNNL-13073. See also www.pnl.gov\aisu.

7. Jeff Logan *et al.*,"Expanding Natural Gas Utilization in China," Pacific Northwest National Laboratory and University of Petroleum, Beijing, (Washington and Beijing: U.S. Environmental Protection Agency and China's State Development Planning Commission), forthcoming July 2001; Logan, J. and D. Luo, 1999. "Natural Gas and China's Environment." Paper presented at the International Energy Agency-China Natural Gas Industry Conference, Beijing (available at http://www.pnl.gov/china/pubs.htm).

8. Pacific Northwest National Laboratory senior research scientist Meredydd Evans won the "International Energy Project of the Year" award from the Association of Energy Engineers for work organizing energy-efficiency investment for the Gostomel Glass Plant in Ukraine.

9. Khozem Merchant in Bombay and David Gardner, "Enron Threatens to Withdraw from Indian Power Project," *Financial Times,* 9 April 2001.

10. Aleksandr Avdiushin, Martin Dasek, Henryk Gaj, Inna Gritsevich, Susan Legro (editor), Jaroslav Marousek, Bedrich Moldan, Natalia Parasiuk, Nikolai Raptsoun, Andrei Sadowski, Vasyl Vasylchenko, Marie Havlickova, Aleksandr Kolesov, Bedrich Schwarzkopf, and Svetlana Sorokina, "No-Regrets Options in Climate Change Mitigation Policy: Lessons from Transition Economies," Battelle, Pacific Northwest National Laboratories, May 1997; Meredydd Evans, "Demand-side energy efficiency and the Kyoto mechanisms", European Council for an Energy-Efficient Economy, 2001 Summer Study, Paper 6.126.