Preface

The nation's economy, environmental quality, defense, and international strategy are inextricably linked to the energy choices we make. To assist the Congress in meeting the challenges associated with these choices, GAO has long been an active participant in the debate on major energy questions. Our previous work has led us to identify five significant issue areas associated with energy policy: energy supply and demand, energy and the environment, management challenges at the Department of Energy (DOE), DOE's nuclear weapons complex, and energy research and development.

On July 10 and 11, 1990, GAO sponsored a conference to examine emerging issues in these five areas. To elicit a wide range of perspectives, we invited representatives from government, industry, research institutions, and citizens' groups to assess the challenges facing the federal government, the states, and business on these topics for the 1990s.

The conference not only provided GAO with a framework for its future work on these important energy issues, but also raised points for consideration by legislators, government agencies, industry decisionmakers, and others concerned with energy policy. We are issuing this report to make the results of the conference available to this larger audience.

This report begins with an overview that highlights the key questions addressed in the five panels, followed by the full texts of the panelists' presentations.

Victor S. Rezendes
Director, Energy Issues
Resources, Community, and
Economic Development Division

Contents

Appendixes

Figures

Abbreviations

ACRS	Advisory Committee on Reactor Safety
APPA	American Public Power Association
Btu	British thermal unit
CAFE	Corporate Average Fuel Economy
CFCs	chlorofluorocarbons
DARPA	Defense Advanced Research Projects Agency
DOD	Department of Defense
DOE	Department of Energy
EEI	Edison Electric Institute
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERDA	Energy Research and Development Authority
F	Fahrenheit
FBI	Federal Bureau of Investigation
FERC	Federal Energy Regulatory Commission
GAO	General Accounting Office
GE	General Electric
GRI	Gas Research Institute
HVAC	heating, ventilating, and air-conditioning
IAEA	International Atomic Energy Agency
IEA	International Energy Administration
IOU	investor-owned utility
IPP	independent power producer
LPG	liquefied petroleum gas (propane)
NASA	National Aeronautics and Space Administration
NCTTA	National Competitiveness Technology Transfer Act of 1989
NRC	Nuclear Regulatory Commission
NWPAA	Nuclear Waste Policy Amendments Act
OECD	Organization for Economic Cooperation and Development
OMB	Office of Management and Budget
OPEC	Organization of Petroleum Exporting Countries
PCBs	polychlorinated biphenols
PEIS	Programmatic Environmental Impact Statement
PUREX	Plutonium Uranium Extraction Plant
quad	quadrillion units of a substance, such as natural gas
R&D	research and development
RCRA	Resource Conservation and Recovery Act
RMI	Rocky Mountain Institute
SEN	Secretary of Energy Notice

SPEERA	Secretarial Panel for the Evaluation of Epidemiologic Research Activities
SPR	Strategic Petroleum Reserve
tcf	trillion cubic feet
WNP-1	Washington Nuclear Plant 1
WPPS	Washington Public Power Supply System

Meeting the Energy Challenges of the 1990s

Balancing Energy Supply and Demand

As we stated in a June 1990 report, a major issue facing the nation is "securing sufficient and reliable future energy supplies to meet the increased U.S. energy demand projected for the 1990s."[1] Key questions in the energy supply and demand equation include: Does the United States have sufficient fossil fuel supplies—coal, oil, and natural gas—to meet growing demand? Can electric utilities adjust to the numerous changes affecting availability of these fuels amidst increasing demand for new capacity? Will end-use approaches such as energy conservation play a greater role in reducing demand? What steps should the nation take in the event of another major oil disruption? To address these issues, the "Balancing Energy Supply and Demand" panelists focused on four specific topics: the future role of natural gas, challenges facing the electricity industry in the 1990s, the importance of energy efficiency in reducing energy demand, and the need to analyze carefully the means used to ensure energy security.

Natural Gas Demand Will Increase

The role of natural gas in the nation's total energy consumption was addressed by Daniel A. Dreyfus, Vice President for Strategic Planning and Analysis of the Gas Research Institute, the natural gas industry's research arm. Demand for natural gas has grown over the last several years and will continue to grow as concerns about environmental quality lead industry to look increasingly to natural gas as a source of supply, he said. Because of the demand for gas to generate additional electricity, Dr. Dreyfus called the electricity industry the "wild card" in influencing natural gas demand. Gas demand could also increase because of policies restricting the use of coal, or other factors affecting coal supplies.

According to Dr. Dreyfus, if the gas industry is to respond to future demand it must remain economically competitive, not only with fuels such as coal, but with other approaches that comply with new environmental policies. He cited the example of the opportunity afforded to gas to compete economically with scrubbers to clean up coal-fired power plants by the Clean Air Act reauthorization legislation.[2]

[1] Energy Policy: Developing Strategies for Energy Policies in the 1990s (GAO/RCED-90-85, June 19, 1990).

[2] At the time of GAO's conference, the Congress was considering amendments to the Clean Air Act (P.L. 95-95). The Clean Air Act Amendments of 1990 (P.L. 101-549) were enacted on November 15, 1990.

Dr. Dreyfus called the North American supply of natural gas plentiful enough to serve projected demand well into the next century, with no problems foreseen in delivery of gas supply or in maintaining the investment in drilling that is necessary to discover and produce the supply.

Electricity Industry Faces Numerous Challenges

Larry Hobart, Executive Director of the American Public Power Association, which represents publicly-owned electric utilities, highlighted four primary challenges for the electric utility industry in the 1990s: environmental constraints, structural changes amid increased competition, increased future demand for electricity, and transmission access.

Growing interest in protecting the environment from industrial processes increasingly influences the electric utility industry, according to Mr. Hobart. Utilities, he said, can address the problem before it starts by "apply[ing] concepts of efficiency to the production of goods and services." To encourage energy efficiency, he said, the Congress enacted laws to promote energy efficient technologies in lighting and to set appliance efficiency standards. He also cited interest in the Congress in mandating the establishment of home energy rating systems.

In recent years, the electric utility industry has witnessed a rise in competition through the creation of non-utility electricity generators.[3] In addition, the 1980s saw what Mr. Hobart called a "strong ideological thrust to change the character of the electric utility industry" and make it more competitive. Independent power producers that only generate electricity and do not control the transmission facilities essential to move power to the customer now exist. In this new competitive environment, weakening the existing regulations may not be the correct course, said Mr. Hobart, noting that some have proposed weakening or repealing the Public Utilities Holding Company Act that regulates the holding companies of investor-owned utilities. Mr. Hobart cautioned that such actions may not be in the best interests of consumers.

Electric utilities should turn to new approaches to satisfy customer demand in the 1990s, Mr. Hobart suggested. One such approach is "least-cost" planning, in which a range of possibilities from energy conservation through customer-generation are weighed. Flexibility is needed, he said, so that electric utilities can consider a variety of fuels—including oil, coal, and gas; nuclear; and renewable energy—and

[3]These include firms such as chemical plants, which use the steam from generators for industrial purposes and to produce electricity, as well as small power producers.

methods of energy production including waste incineration and cogeneration, which produces both electrical and thermal energy from the same source.

Mr. Hobart emphasized the need for more effective regulation over transmission of electricity, calling it "the key to control of electricity." He suggested a stronger role for the Federal Energy Regulatory Commission in regulating transmission access through its rate-making powers.

Additional Energy Efficiency Opportunities Exist

Amory B. Lovins, Vice President for Research at the Rocky Mountain Institute, a private, nonprofit research firm studying resource efficiency and global security, noted that the nation has made significant advances in reducing its demand for energy. The national energy bill has decreased by about $150 billion per year, he said, but the nation could make even more progress by using energy efficient technologies and by saving oil. Using energy efficient technologies would involve, for example, retrofitting existing equipment such as lights and space- and water-heating, and moving toward more fuel efficient automobiles. Saving electricity and using less oil would also lessen environmental problems caused by acid rain, smog, and global warming, he said.

According to Mr. Lovins, utilities as well as their customers benefit from saving electricity, regardless of available capacity, because decreased revenues from selling less electricity are outweighed by cost savings. Mr. Lovins noted further that the National Association of Regulatory Utility Commissioners has agreed to a policy that would reward utilities that save electricity by allowing them to keep part of their savings as extra profit.

Mr. Lovins called on the Department of Energy to refocus its policies on the end use of energy sources. DOE, he said, "ought to start by asking what specific end use a given increment of energy is needed for, and how much energy, of what type, at what scale, from what source will meet that need in the cheapest way."

Energy Security Needs Further Definition

Douglas R. Bohi, Director of the Energy and Natural Resources Division at Resources for the Future, an independent nonprofit research organization, reviewed what he considered the unanswered questions about energy security in relation to supply disruptions, oil price mechanisms, and the role of the Strategic Petroleum Reserve (SPR).

Concern about the nation's dependence on imported oil, he said, has rested on the belief by experts that a recession will result if energy prices rise quickly in response to a disruption and the economy is not able to adjust. He attributed this belief to the experiences of the United States after the oil disruptions of 1973 and 1979.

In contrast to this belief, Dr. Bohi cited the examples of Japan and the United Kingdom. Japan, he said, did not experience a recession in 1979, although it was much more dependent than the United States on imported oil. In the same period, the United Kingdom experienced the deepest recession among the industrialized countries, although it was approaching oil self-sufficiency. Because of these apparent contradictions, Dr. Bohi called for further study of this disruption-recession linkage concept.

Dr. Bohi reviewed the two policies most often suggested to prevent the price of oil from rising to destructive levels: reducing demand for imports through a tariff or increasing supply through the release of oil from the SPR. If we accept the assumption that a recession will result from a sudden increase in oil prices, he noted, a tariff may not be the right strategy since it would further increase domestic prices.

Tapping into the SPR, he added, might also fail to lower oil prices, especially if the inventory building and hoarding experienced in the past were repeated. Partly because of changes in the oil industry in the last 10 years that reduce the potential for the hoarding that took place during previous supply disruptions, Dr. Bohi called for further study into the effectiveness of the SPR in controlling prices before its size is increased.

Energy Choices and the Environment Increasingly Linked

Virtually every process requiring energy produces waste and that waste can threaten human health and environmental quality. Panelists participating in the "Energy and the Environment" session agreed that energy policymakers in the 1990s must come to grips with the environmental effects of their decisions about energy use, and discussed some of the critical choices that must be made in relation to these effects. The panelists addressed the links between global warming and the fossil fuels that now produce nearly 90 percent of the nation's energy; concerns about environmental, economic, technological, and other impacts of the 1990 amendments to the Clean Air Act; the challenging transition to alternative fuels for automobiles; and the problem of safely disposing of the wastes produced through the generation of nuclear power.

Responding to Global Warming

James J. MacKenzie, Senior Associate in the World Resources Institute's Climate, Energy and Pollution Program, addressed the issue of fossil fuel use, which is the primary source of carbon dioxide emissions as well as other "greenhouse" gases that contribute to global warming, ozone pollution, and acid rain. Two-thirds of carbon dioxide emissions arise from electric utilities and transportation activities, and "increasing electrification and the growing number of vehicles on our roads" will only contribute to this upward trend, he said.

Calling for reductions in fossil fuel consumption, Dr. MacKenzie said public policymakers must develop long-term strategies that fully take into account interrelationships among the use of fossil fuels and climate change from greenhouse warming, air pollution in the form of acid rain, and the nation's growing reliance on imported oil.

In the transportation sector, Dr. MacKenzie said solutions should include highly fuel efficient vehicles, variable sales taxes or variable annual registration fees that are higher for less fuel efficient vehicles, and "carbon fees" on fossil fuels. Long-term investment in public transportation would reduce the number of vehicles on the road, he said. Dr. MacKenzie saw limited use of cleaner fossil fuels such as compressed natural gas as a short-term solution, and endorsed a long-term move toward hydrogen-powered and electric vehicles.

Clean Air Act's Impact on Energy

Michael T. Woo, professional staff member of the Committee on Energy and Commerce, U.S. House of Representatives, outlined some of the questions the Clean Air Act Amendments of 1990, enacted in November 1990, will be likely to raise.

Environmental questions will be raised, according to Mr. Woo, as to whether "the claims of the amount of reductions in acid rain, chlorofluorocarbons, ozone-forming compounds, and air toxic emissions" will actually be achieved.

Determining the costs associated with the act's directives will present another difficulty. Mr. Woo noted that cost estimates range from industry's prediction of hundreds of billions of dollars to claims by the environmental community that some costs for health care are foregone by having cleaner air.

The Congress will also be concerned with how well the act is working, said Mr. Woo. He pointed out, for example, that to reduce acid rain, electric utilities will be required to achieve significant sulfur dioxide reductions, forcing some utilities to adopt new emissions control technologies. To lower the cost of these reductions, a new system of market-based incentives that would allow utilities to sell pollution rights to other utilities may be adopted, he said. The Congress will want to know how well this system works.[4]

The Congress, Mr. Woo added, will also want information about the technological feasibility of some of the Clean Air Act requirements. One of the basic debates over many individual provisions of the bill, said Mr. Woo, concerns whether the act's implementing regulations should be "technology forcing"; that is, whether the legislation should force industries to adopt technology that may not currently exist. Goals and standards established by the Congress that may not be immediately technologically feasible could be feasible in 5 or 10 years, he noted.

Compliance, said Mr. Woo, is another important consideration for the Clean Air Act amendments. The Congress will be interested, he said, in monitoring not only the progress of utilities in moving to comply with certain targeted deadlines for the allowance trading system, but also whether or not they do comply.

Obstacles to Alternative Fuels

Roberta J. Nichols, who manages Ford Motor Company's alternative vehicle design department, discussed alternative fuels, calling the development of a market for these fuels "the biggest systems engineering challenge anyone could possibly put on the table, not only on the environmental issues but also for national security and our competitive position in a world market." She described both the benefits of the alternative fuels being studied and the hurdles that face the automotive industry in adopting these fuels.

Passenger cars operating on gasoline have achieved significant reductions in hydrocarbons and carbon monoxide emissions, Dr. Nichols said, but have failed to achieve compliance with federal air quality standards for ozone. More significant reductions in oxides of nitrogen and the photochemical reactivity of hydrocarbons in the atmosphere—which are the primary contributors to noncompliance with ozone standards—can be achieved with some of the alternative fuels, she explained. Cars that

[4]Such a system is now required under the 1990 law.

run on methanol, natural gas, and reformulated gasoline offer an advantage over gasoline in reducing ozone, but concerns exist about the ability of natural gas vehicles to meet future nitrous oxide emission standards.

Alternative fuel vehicles also face marketplace hurdles. Lack of sufficient refueling stations for methanol cars has contributed to consumer resistance in California, for example. "Flexible fuel" vehicles, which can run on methanol or gasoline or any random mixture and still offer a performance increase, may offer an attractive choice for consumers, she said.

Driving range is another impediment for alternative fuels cited by Dr. Nichols. While the alternative fuels are more energy efficient—allowing cars to travel more miles per energy unit than they can on gasoline—alternative fuels produce less energy on a volume basis than does gasoline, so vehicles require larger tanks to travel the same distance.

Although reformulated gasoline can be used in all existing gasoline vehicles already on the road, Dr. Nichols considered this an interim move, with methanol as the long-term replacement for petroleum-based fuels. She viewed ethanol, derived from corn, less positively because it costs more. Gaseous fuels (liquefied petroleum gas and compressed natural gas), although applicable in fleet vehicles and less expensive, require more costly high-pressure tanks. Customer satisfaction, however, will remain the overriding factor in determining the success of alternative fuels, according to Dr. Nichols.

The Nuclear Waste Dilemma

Ben C. Rusche, Senior Vice President and Manager for Government Services of Law Environmental, Inc., an environmental engineering firm, addressed the issue of nuclear waste disposal, stating that "finding solutions to the high-level waste issue is crucial, if not paramount, in permitting nuclear power to find its proper place in the mix of energy sources for the United States and, indeed, for the world."[5]

The question regarding nuclear waste, said Mr. Rusche, is "how, when, and where do we place the material to allow nature to take its course?" Social and political issues are more serious than engineering issues in solving the problem, he said, including questions as to who is in charge,

[5]Although high-level nuclear waste includes "spent" nuclear fuel from DOE defense production activities and from commercial nuclear power production, Mr. Rusche's remarks dealt with commercial nuclear waste. In the case of commercial nuclear power, spent nuclear fuel is the uranium fuel that has been removed from a nuclear reactor when it is no longer useful in producing electricity.

the level of acceptable risk, who is to pay, and how government can communicate these ideas to the public.

Mr. Rusche called nuclear waste, like hazardous waste and air pollution, a national problem requiring federal attention. The Nuclear Waste Policy Amendments Act of 1987 provides a reasonable basis on which to proceed, he said. but community opposition to potential siting of disposal areas may place the final decision with the courts.

National programs or actions for solving the nuclear waste problem must include safety and environmental standards based on reasonable assurance, continued involvement and communication with the public, and establishment of schedules that are reliably carried out, Mr. Rusche concluded.

Confronting Management Challenges at DOE

Effectively managing the Department of Energy is a challenge compounded by DOE's diverse missions, chief of which are producing nuclear weapons for the nation's defense, establishing non-defense energy policies, and overseeing long-term research projects. The members of the "Managing the Department of Energy" panel provided an overview of the management challenges facing the Congress and DOE regarding these missions. These panelists agreed that DOE must address the problems associated with its heavy reliance on contractors to carry out programs. Panelists also discussed longer term management issues such as whether to transfer DOE's nuclear weapons production functions to the Department of Defense and how DOE can better fulfill its energy policy-making role.

Joseph S. Hezir, Deputy Associate Director for Energy and Science, Office of Management and Budget, said DOE's reliance on contractors for program execution makes management roles and responsibilities unclear. A review of DOE's work, said Mr. Hezir, must also take into consideration some other common characteristics of its programs:

- They are expensive and multi-year in nature but must compete for budget resources annually.
- Many involve scientific and technical uncertainties about which expert opinions differ, and many are one-of-a-kind projects, making comparisons difficult.

- They involve extensive, complex, and sometimes contentious interactions with outside groups such as state and local governments, environmental groups, and other federal agencies such as the Department of Defense.

DOE's internal oversight mechanisms, such as the Office of the Inspector General, the Office of Policy and the Comptroller's Office, play important roles in ensuring coordination and consistency across the Department, said Mr. Hezir. In addition, Secretary Watkins has issued directives—aimed at ensuring coordination and consistency across the Department—to correct what he sees as some of the management problems.

John C. Layton, the Department of Energy's Inspector General, said that when he joined the Department in 1986, DOE's operations offices believed that they held most of the authority. DOE's management philosophy is changing, he said.

A turning point for DOE management, said Mr. Layton, was the 1989 raid on the Rocky Flats facility in Colorado, conducted by DOE's Inspector General, along with the Federal Bureau of Investigation and the Environmental Protection Agency.[6] Secretary Watkins subsequently established "Tiger Team" exercises that focused additional attention on DOE's management, accountability, and responsibility in the field.

Examining the question of responsibility, Mr. Layton said that DOE no longer follows its past theory that the Department hires a contractor who is then held responsible. However, DOE has approximately 16,000 permanent employees, but employs roughly 135,000 to 160,000 contractors, according to Mr. Layton. He questioned whether this represented the "right mix of people," given the operations offices' authority and responsibility for overseeing the contractors.

DOE's nuclear weapons production facilities are a major management challenge, said Mr. Layton, partly because of deferred maintenance. The problem of storing the nuclear waste from these facilities properly and safely is another management challenge as well as a major legal issue for the Department.

[6] The raid was conducted because of alleged regulatory and criminal violations of environmental law at the plant site.

According to Mr. Layton, the Inspector General's office recently issued a report on an audit of DOE's major systems acquisitions. The Department, he said, has a "track record of failed big projects coming in late, over cost, over budget, or never being started—just canned." If policies and procedures for the acquisitions had been followed, said Mr. Layton, there may have been fewer of these "historical disasters."

Leonard Weiss, Staff Director of the Committee on Governmental Affairs, U.S. Senate, also cited DOE's reliance on contractors as possibly the major management issue at DOE. Lack of adequate records detailing contractor activities and a lack of clear understanding at headquarters in Washington, D.C., of what functions contractors perform continue to be problems. Nor does DOE routinely provide detailed information about contractors to the Congress, said Dr. Weiss. He also highlighted more recent problems, including large amounts of sole-source contracting and lack of effective priority-setting for spending on energy research and development projects.

Another management challenge arises from the lack of qualified personnel, and Dr. Weiss cited low pay as one reason for DOE's loss of expertise and talent. The Senate Committee on Governmental Affairs attempted to address the problem, he said, by producing a pay reform bill.[7]

Potential changes in the nation's defense and non-defense energy requirements indicate a need to revisit the long-standing debate over whether to transfer the nuclear weapons activities from the Department of Energy to the Department of Defense, Dr. Weiss noted.

Addressing Problems Within the Nuclear Weapons Complex

The Department of Energy operates the nation's nuclear weapons production facilities, a complex consisting of 16 major installations located around the country. However, many of DOE's major production facilities, including those in Hanford, Washington, and Rocky Flats, Colorado, are currently shut down because of safety risks and enormous cleanup problems. GAO estimates that it will cost as much as $155 billion over at

[7] Legislation making salaries of key federal positions more competitive with the private sector is contained in the Federal Employees Pay Comparability Act of 1990, which was included in the Department of Treasury, Postal Service, the Executive Office of the President, and Certain Independent Agencies Appropriations Act for Fiscal Year 1991 (P.L. 101-509, section 529).

least 25 years to clean up and modernize a number of DOE's facilities.[8] While the future of the weapons complex remains uncertain, participants in the "Producing Nuclear Weapons Safely" panel identified a number of issues requiring resolution. These included the task of setting priorities and standards for cleanup, the potential for wasting funds on ineffective cleanup approaches, the proliferation of overlapping oversight and assessment groups, and the need to weigh both acute and long-term health effects in studying exposure to radiation.

Setting Priorities and Standards for Cleanup

Richard A. Meserve, a partner in the law firm of Covington & Burling who has chaired two National Academy of Sciences committees on DOE nuclear weapons issues, discussed the committees' recommendations for addressing problems at the nuclear weapons complex. Dr. Meserve described the contamination at the complex as extensive, and not limited to radioactive waste. He stated that cleaning up the associated chemical wastes is also a serious problem, sharing many similarities with the cleanup of Superfund and other hazardous waste sites.

DOE must set cleanup priorities to avoid the problems that beset Superfund and the other waste programs, said Dr. Meserve, in which federal dollars went to "the site where there is the most noise rather than . . . the most risk." Dan Reicher, a senior attorney with the Natural Resources Defense Council who has led challenges to DOE's compliance with environmental laws at its nuclear weapons production facilities, agreed with Dr. Meserve's assessment. Setting priorities is not simply a matter of cleaning up the most threatening sites first, he said. Issues that will complicate priority-setting, according to Mr. Reicher, include competition among the states for limited cleanup funds, environmental problems at other federal facilities across the country that draw attention away from DOE's problems, public opposition to targeting of funds, and the different priorities of DOE and the Congress.

Choosing which sites to clean up may require establishing "national sacrifice zones" where untreated radioactive or chemical wastes are left in the environment, according to Mr. Reicher. Dr. Meserve stated that, because we cannot afford to clean up every site to the level some would demand, cleanup levels need to be set either through a "risk calculus,"

[8] Nuclear Health and Safety: Dealing With Problems in the Nuclear Defense Complex Expected to Cost Over $100 Billion (GAO/RCED-88-197BR, July 6, 1988) and Efforts to Improve DOE's Management of the Nuclear Weapons Complex (GAO/T-RCED-90-64, Mar. 28, 1990).

or through a uniform standard. But since each site has unique characteristics, different standards will have to be established for each site to be cleaned up, he added.

To avoid future cleanup problems, the federal government, said Dr. Meserve, needs to seize the opportunity to use technologies to minimize waste from the production process, so that "we don't leave a legacy for future generations like that which we have to confront."

The weapons complex cleanup task may compete with the savings and loan crisis as "one of the great unfunded liabilities by the turn of the century," Mr. Reicher said. Identification of further contamination problems at sites and new cleanup standards could also drive up costs, according to Mr. Reicher. DOE estimates of cleanup costs increased by more than 60 percent in its most recent 5-year plan, he said.

Mr. Reicher cited potential impediments to efficient and effective accomplishment of the cleanup task, including lack of effective oversight of DOE's and the contractors' cleanup operations, a tendency to spend too much time studying the problem, failure to employ interim remedies that could slow or halt the spread of contamination in the short term while more permanent remedies are assessed, potential for fraud and abuse, and overemphasis on "exotic and complex cleanup technologies that may prove to be inadequate."

Mr. Reicher argued for a better balance of funding and an open dialogue in discussions of modernization of the weapons complex. Public support for DOE's efforts is critical, he said, calling for increased public access to information and opportunities for meaningful participation.

Dr. John F. Ahearne, Executive Director of Sigma Xi, The Scientific Research Society, who also chairs DOE's Advisory Committee on Nuclear Facility Safety,[9] identified additional problems associated with environmental cleanup at the facilities. In 3 or 4 years, he warned, GAO may report that "large amounts of money were wasted [on the cleanup effort] and not much has happened." For example, he expressed concern about the cleanup agreements reached between DOE and the states in which the facilities are located. Although the conclusion of these agreements may

[9]The Advisory Committee on Nuclear Facility Safety, established by DOE, is a 15-member panel of experts from outside the Department of Energy who advise the Secretary of Energy on matters related to the safety of DOE nuclear facilities.

indicate political success for DOE managers by getting local environmental agencies "off their backs," he questioned whether the agreements would be cost-effective for the nation.

Oversight, Modernization, and Safety Are Ongoing Issues

Further study is needed, said Dr. Ahearne, on a number of issues regarding the future of the weapons complex. He pointed to "the proliferation of oversight and assessment groups" advising DOE both internally and externally as one such issue. Not enough competent people exist to staff all of these groups, Dr. Ahearne's committee wrote, in a letter to Secretary Watkins. Overlap is an additional issue cited by Dr. Ahearne. He questioned whether his committee still has a role, given the creation of the Defense Nuclear Facilities Safety Board. Furthermore, he observed that many other issues the board is examining have already been worked out by the Nuclear Regulatory Commission.

Changes in Eastern Europe and the Soviet Union mean that DOE's study of modernization needs in its weapons production facilities should be assessed to determine if these world political changes have been considered, said Dr. Ahearne. In this context he questioned the necessity of rebuilding Building 371 at Rocky Flats and finishing the WNP-1 plant [at Hanford], now a commercial facility, for use in weapons production.

DOE lacks a safety policy for its operations, said Dr. Ahearne, and "it is not clear there is much progress towards it." Instead of allowing orders and rules to flow from an overall safety policy and safety goal, he contended, DOE's safety policy is evolving from an "order revision and rulemaking effort." According to Dr. Ahearne, DOE missed an opportunity to apply the safety lessons learned by the commercial nuclear energy sector following the accident at Three Mile Island to DOE's nuclear weapons facilities.

Health Risks to Both Workers and Residents Need Further Study

Clark W. Heath, Jr., M.D., Vice President for Epidemiology and Statistics at the American Cancer Society and a member of the SPEERA panel,[10] discussed some of the findings of that panel as well as issues related to the health and safety of workers in the weapons facilities and residents of nearby communities.

[10]The Secretarial Panel for the Evaluation of Epidemiological Research Activities (SPEERA) was established to provide the Secretary of Energy with an independent evaluation of DOE's epidemiology program and the appropriateness, effectiveness, and overall quality of DOE's epidemiologic research activities.

Four common features, according to Dr. Heath, characterize health concerns for both workers and residents. First, risks stem from exposure to radiation and from a variety of chemicals used in weapons production. Second, to trace health effects requires the difficult task of reconstructing past events. The effects of current exposures may not be evident for 10, 20, or 30 years, he said. Third, the public may perceive a lack of credibility and openness on the part of those studying health effects, compounding "what may otherwise be fairly objective matters." Finally, more data are needed to determine the health effects of exposure to low doses of radiation. Valuable data may be available from studying the health records of workers from the 1940s and 1950s at some of DOE's oldest weapons facilities.

Both the acute health effects usually related to high-dose radiation exposure and delayed effects such as cancer must be examined in studying occupational exposures, Dr. Heath stressed. One of the strongest of SPEERA's 55 recommendations, he said, was that DOE reorganize its occupational health program to take into account the health risks that workers bring to the workplace as well as workplace risks from chemicals, noise, and injuries. Although many DOE sites contain many elements of a comprehensive health program, their programs seemed uncoordinated in terms of centralized communication, Dr. Heath said.

To determine the threats to people living in communities near the weapons facilities, precise information on exposures and doses is also essential, said Dr. Heath. He supported the approach researchers are taking to reconstruct exposures as carefully as possible in places such as Rocky Flats and Hanford before proceeding to full-scale epidemiologic studies.

New Directions for Federal Energy Research and Development

Federal energy research funds have been provided not only for high risk, long-term projects such as high energy physics and the Superconducting Super Collider, but for research and development in fossil fuels, solar and renewable energy, nuclear energy, and energy conservation. Some participants in the "Opportunities for Energy Research and Development" (R&D) panel pointed out that it may now be appropriate to refocus part of these funds to projects that provide more immediate payoffs. The panelists agreed that an expanded federal role is needed, for example, to assist in the transfer of energy technologies into the marketplace. Opportunities the panelists identified for enhancing the federal government's role in energy R&D included: using the National Energy Strategy and recent legislation to make technology transfer a major DOE mission; strengthening links among the federal government, states, and private industry through public-private partnerships and consortia-building; and increasing investment in energy efficiency research activities.

Why Energy Research and Development Programs Fail

Dr. Linda Cohen, Assistant Professor of Economics at the University of California, Irvine, noted that the history of federal involvement in research and development commercialization projects "is not a happy story." Dr. Cohen's forthcoming book, The Technology Pork Barrel, examines the federal government's efforts to commercialize new technologies and discusses why three energy programs—synthetic fuels development, the breeder reactor, and photovoltaics—failed in this objective. The three energy programs did not succeed, according to Dr. Cohen, because the programs were too narrowly defined to meet their objectives. The programs were also subject to a "boom-bust" phenomenon: that is, the political support for the programs would evaporate as conditions changed—when energy prices dropped and funding was subsequently withdrawn, for example. In addition, once the federal government undertook the projects, said Dr. Cohen, the research was perceived by established firms as threatening. Many programs also had huge cost overruns, which were then financed by taking money from other research programs, hurting those efforts.

Clearer Focus for Energy R&D Policy

James L. Wolf, Executive Director of the Alliance to Save Energy, a non-profit coalition of business, government, labor, and consumer leaders working to increase energy efficiency, asserted that "we have, in this country, no comprehensive approach to research and development, whether it be energy research and development or any other industry." Funds have been directed to the energy supply industries (electric generation from nuclear power and coal, natural gas, and oil) because they have the most clout, he said, reducing attention on energy efficiency.

The energy efficiency industry's relatively small size, its dispersion, and the DOE requirement that most recipients of its R&D funds engage in cost-sharing have hurt the industry's ability to compete, said Mr. Wolf, and may "screen out the most innovative start-up firms." The Department, he pointed out, conducts many cost-share projects with the energy industry research groups—the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI), for example. But, he added, the fact that these organizations have the money to cost-share does not mean their projects should receive high federal priority.

According to Mr. Wolf, even though Americans invented many of the technologies associated with energy efficiency, the United States lags behind its Japanese competitors in commercialization. He cited the ceramic rotor used in automobile turbo chargers as an example of an energy efficiency technology developed in the United States that Japanese manufacturers have been more willing to adopt. One way the federal government could assist the efficiency industry is by helping commercialize the products of government-funded research by purchasing the products. The government could, for example, buy and use high efficiency light bulbs for federal buildings. Research into lights and motors—which use almost 40 percent of the nation's electricity—presents another opportunity for federal involvement, because neither EPRI nor GRI has undertaken such research.

DOE should refocus its energy R&D budget to meet the energy challenges of the 1990s, rather than those of the 1970s, Mr. Wolf contended, directing R&D "where issues like energy, the environment, and the economy are complementary." DOE needs managers who can spot potentially successful projects into which to channel R&D funds, he said, such as DOE's $2.7 million investment in research on electronic ballasts for lighting.

Improving Technology Transfer

Cherri J. Langenfeld, Acting Director of DOE's Office of Technology Policy, discussed the implications of the National Energy Strategy for research and development. The National Energy Strategy has already increased DOE's emphasis on technology transfer activities, she said, bringing defense program staff together with other DOE program offices on technology transfer projects to an unprecedented extent. Ms. Langenfeld said that regardless of what research and development plan finally evolved, "our goal is to make sure that that research is, in fact, used by somebody."

DOE is also responding to the National Competitiveness Technology Transfer Act of 1989, which makes technology transfer a primary mission for DOE and the national laboratories, Ms. Langenfeld said. To achieve that mission, DOE will define technology transfer roles for headquarters, field offices, and the national laboratories. Challenges facing the Department in shaping a technology transfer program include choosing companies for public-private partnerships, identifying both potential sources of funding and the term of project funding, sharing information with the private sector, and developing methods of evaluating technology transfer projects.

Stronger State-Federal Partnerships Are Needed

Dr. Irvin L. (Jack) White, President of the New York State Energy Research and Development Authority, discussed how the federal government can assist states in energy research and development. One of the most important things the Department of Energy can do to help the states, he said, is to complete the National Energy Strategy. The National Energy Strategy will "state clear objectives to guide DOE's energy R&D planning."

Since R&D resources are scarce, Dr. White said, it is essential "to develop a common understanding within the energy R&D community of what the high priority energy R&D needs are." To accomplish this, DOE should take the lead in identifying energy R&D choices, as well as the environmental, social, and economic implications of these choices. Such leadership, Dr. White said, would not only bring together a "fragmented" energy community, but would include other federal agencies such as the EPA.

In the area of technology transfer, according to Dr. White, DOE should consider identifying certain energy industries in which DOE would lead public-private consortia for promoting energy efficiency improvements. He identified the electric utility industry, lighting, and energy storage as potential areas for increased federal involvement in research.

The government can help manage the risks associated with process changes and new technologies, Dr. White said. He added that "only the people who will be making the changes can decide what process changes or new technologies they are willing to invest in." Furthermore, most industrial and commercial managers are reluctant to be the first to introduce either significant process changes or new technologies. Dr. White suggested that DOE adopt a consortia-building strategy in energy research and development—particularly in areas such as energy efficiency that have national policy implications—modeled on the industry research programs of the Gas Research Institute or the Electric Power Research Institute.

Panel 1: Balancing Energy Supply and Demand

Daniel A. Dreyfus
Gas Research Institute

"... the intensifying environmental dialogue has convinced some people, both in and out of the gas industry, that there will be a strong policy bias favoring the choice of gas in the future ..."

I would suggest to you that as this conference goes on you keep your eye on electricity. When I look at the future of the United States with regard to energy, the glaring uncertainty and the major wild card is the electric situation. There is considerable uncertainty about how much electricity we will need, and much more widely variable options with regard to scenarios for electricity than anywhere else in the energy outlook.

I think the critical questions will be how much electricity we will, in fact, need and where we will get it. When you look at the supply situation, it tends to turn on the question of primary energy for the generation of electricity, and the options are not really very encouraging.

We conventionally expect to depend very heavily on coal for electricity. Anybody who has been following the environmental movement for the last 2 or 3 years knows there are some uncertainties there.

The nuclear option is pretty much at a standstill. Everyone knows about the public opinion aspects of that. I think what is overlooked is that there are some fairly substantial financial risks associated with managers making the nuclear choice.

Oil, I think, is going to play a much bigger part in future electricity than most people suspect. The demand for oil is going up in the utility sector, and it is likely to go up a great deal faster than expected and add to the import problem.

Of course, I'll get into the natural gas portion of this in a little more detail. Natural gas has gained a lot of renewed interest in the public policy arena in recent months. Gas markets have been in disarray for several years, but they appear to be strengthening. In fact, the demand for gas has grown over the last 3 years. More prominently, the intensifying environmental dialogue has convinced some people, both in and out of the gas industry, that there will be a strong policy bias favoring the choice of gas in the future and that it presents either substantial market opportunities or, from the point of view of the public policymaker, substantial increased dependence on gas in the national energy mix.

Whenever the prospects for gas are mentioned, however, there are always skeptics who question the supply and the price for the future. The question of natural gas availability—how much and at what price—is not exclusively a matter of geology. Obviously, there has to be gas somewhere if you are going to find it and produce it. But most of the potential users of gas don't intend to look for it and they don't intend to drill the wells. They expect to buy their gas from a utility or a merchant and have it delivered to the point of use.

So the price and quantities of delivered gas depend upon two principal factors: the geology that ultimately makes the resource available and dictates some portion of the price and—I think more importantly, especially in the near term—a flow of investment into the exploration, production, and transportation of gas to the user.

Now, any new uses for gas have to be considered as an incremental requirement imposed upon a supply system that is already operating. The first consideration, therefore, is how the gas supply in the United States stacks up in view of current and conventionally expected demand—that is, the demand that is likely to occur because of the economic evolution of the energy marketplace.

Then, we can consider the probable impact upon this baseline outlook of any incremental requirements for gas that may be created by some dramatic alteration in the marketplace, such as a policy initiative or a restriction on another energy source.

The historic markets for gas in the United States are pretty well established, and most uses of gas are tied to substantial long-term investments in energy-using equipment, such as home furnaces and industrial process technologies. There is, however, a significant segment of industrial and electric utility gas users who are capable of switching from gas to other fuels in existing equipment. They constitute both a market discipline on prices for gas and a source of potentially volatile demand to be met by the industry.

Today, however, the price relationships among alternative fuels are in rough equilibrium. I conclude that because there are no major shifts now taking place among the fuels currently being used. So we can expect that the current trends in the traditional gas markets will remain pretty persistent. Current annual demand for natural gas is about 19 quadrillion Btu (British thermal units), or quads. About 25 percent is consumed in the residential sector; 15 percent in the commercial sector; 40 percent in industrial uses, including agriculture; and 15 percent by electric utilities. About 3 percent of the gas is used in the transportation sector, primarily by the gas industry in pipeline compressor stations.

Overall, gas demand has been growing for several years. When the vagaries of the weather and the economic cycles are smoothed out, traditional gas markets can probably expect an average annual demand growth of a little over half a percent in the future.

In the residential and commercial sectors, high efficiencies of modern equipment and building stock as they replace the older stuff will offset the growth in the number of gas-using customers. Residential gas demand—indeed, residential energy demand—is likely to remain flat at today's level.

The successful introduction of commercial-sized gas cooling technologies, which are now becoming available, and the overall growth in commercial sector activity will probably result in some growth in gas demand in the commercial sector—office buildings, hospitals, fast-food facilities, hotels, and that sort of thing.

After nearly a decade of steady decline, industrial consumption of energy turned up sharply in 1987, and natural gas participated in the trend reversal. Low energy prices and a resurgence of the export market probably influenced this recent experience, but from a total energy point of view it also probably represented the end of the erosion of the U.S. heavy industry base. So I think we can expect that, again leveling out the cyclical economic activity, industrial energy use in the United States will now grow gradually over the next decade or so.

Our projected growth in electricity demand will provide an opportunity for increased use of natural gas by electric utilities, and that, indeed, is happening. As the demand for electricity outstrips the capacity of existing generating facilities—which initially and currently is happening at times of peak demand and later will happen more generally—gas will offer a competitive edge for new peaking facilities that use gas turbines and, hopefully, combined cycle technology. These technologies have a low capital cost and short construction lead times.

The growth in these traditional markets, which can be projected on the basis of historical experience and economic assumptions, would increase the annual requirement for delivering gas from about 19 quads today to about 21 quads in 2010—not a very exciting or intimidating growth. We have, in fact, delivered as much as this in past years. The future supply and demand patterns, of course, will be different from those of the past and will require some pipeline additions, but we see no technical or financial barrier to meeting this level of requirement over the next 20 years.

The new uses for gas that might emerge from policy changes have to be considered as an increment against this "business as usual" outlook. New requirements are either going to compete for or add to the amount of gas that is being delivered.

It is important to remember that the success of natural gas in gaining new environmental markets or other markets depends largely upon policy initiatives that create these new applications, which do not, in fact, exist today. But these policy initiatives must not foreclose the gas options. Success in gaining new markets will also depend upon the capability of available gas technologies to compete economically against other approaches that can comply with new policies.

In other words, using an example, the pending clean air legislation may give gas an opportunity to compete with scrubbers to clean up coal-fired power plants.[1] But the legislation will not provide a guaranteed market and, in fact, it may subsidize the scrubbers. So the actuality of economic competition remains to be seen.

The estimates that I have seen are excessively optimistic about new environmental markets for gas. We believe that a total potential gas demand for methane vehicles, emission control in coal-fired facilities, and waste incineration will probably range between about 1.4 and 5.2 quads in 2010. Now that's a wide range, and the high end would, in fact, be an impressive incremental requirement. But it is predicated upon a lot of hopeful and optimistic assumptions. I think the lower end of that range is probably more likely—one or two quads added for environmental uses.

The electric utility sector is more of a wild card. The future demand for gas to generate electricity may be very high if, in fact, electricity demand grows more rapidly than we have projected or if, in fact, something happens to one of the alternative fuels—for example, if severe constraints are placed upon the use of coal.

[1] At the time of the conference, the Congress was considering amendments to the Clean Air Act Amendments of 1977 (P.L. 95-95). The Clean Air Act Amendments of 1990 became law in November 1990.

We expect electric utility gas demand to grow from about 2.7 quads now to about 4.3 in 2010. We would expect, however, that at the extreme upper limit demand might reach something like 6.3 quads in 2010 rather than the 4.3 that we project. So there is probably potential for another 2 quads of gas demand in the electric utility sector if electricity demand grows more rapidly or something happens to coal.

I would reemphasize that we are expecting to use about 27 quads of coal in 2010 in the United States—about 40 percent more than we used last year. That is clearly problematical. On the other hand, if you decide not to use that coal, it is not at all clear where the alternative fuels would come from.

So, overall we could add about 1 to 4 quads to our baseline projection of gas demand in 2010 if some of these uncertainties were to fall in the direction of gas.

What about the supply? I would dispose of the resource question that was prominently but illogically debated for a couple of years. There is enough gas in the rocks of North America to serve the projected demand, with or without the increment, well into the next century. Authoritative estimates of economically recoverable gas resources are about 1,000 tcf (trillion cubic feet), or about a 50-year supply. In anything as uncertain as those kinds of estimates, a 50-year supply is about all you want to be worried about.

Ten percent of our current gas demand is met from supplements and imports. Ten percent of the future need will probably come from these same sources.

We see no particular problem with delivering gas in light of the gas industry's past capabilities. We see no particular problem in maintaining the investment in drilling that is necessary to discover and produce the supply that we project.

Overall, U.S. financial markets are large, and small increases in gas development would be unlikely to change the rates of return on drilling investment that would be required to get the money.

We have concluded that an incremental supply of 2 tcf above the baseline could be accommodated pretty much within the portfolio of supplies that we have projected and without very much change in the price track.

If, on the other hand, you look for the 4 or 5 tcf associated with some of the more extreme scenarios, the supply would be more difficult to get—primarily for financial reasons. You would have to have more Canadian imports in the near term. You would have to escalate large capital projects such as arctic pipelines and liquified natural gas projects in the longer term; and the escalation in prices would have to be greater.

In summary, the outlook for gas markets, I think, is not particularly difficult to comprehend. There are the evolutionary market trends, which are reasonably predictable and have considerable inertia. There are some potential market opportunities that I think, like most departures from the norm, are likely to prove to be smaller than expected. There are no technical or financial obstacles to providing adequate and reliable supply responses.

As in every other business endeavor, the challenge to the gas industry will be to make timely investments based upon rational risks. If the industry does not do so, the marketplace will make the adjustment. Unlike electricity, there is almost no significant use for gas that is not capable of being served by some other reasonably convenient and economically feasible energy source. So the demand for gas rests upon competent service and competitive prices. If the industry falls short of either, then the market adjustment will be relatively swift.

Larry Hobart
American Public Power Association

The American Public Power Association (APPA), which represents publicly owned electric utilities around the country, has often been a source of information for the U.S. General Accounting Office, and Dexter [Peach, Assistant Comptroller General, Resources, Community, and Economic Development Division, who opened the conference] and I have worked on many projects over the years. But we rely very heavily on you as a source of information, also. Your reports in the energy and environment area are a permanent part of our library, and we use those materials on a continuing basis to check our numbers and to learn new things about the industry that we attempt to represent.

Dexter, in his opening remarks, has sketched out changes that have taken place over recent decades, and they can be easily categorized in the electric utility area.

The decade of the 1970s was shaped by the Arab oil embargo and by the price shocks subsequently experienced in 1979. It was a period of high inflation and high interest rates. We learned an important lesson that the electric utility industry initially did not believe: the demand for electricity is, indeed, elastic. What we saw in the 1970s was not an aberration but was something that we had to take into account for the future.

In the 1980s, public policy and economic decisions in the electric utility industry were driven by the existence of a surplus of generating capacity in virtually all parts of the country. Those electric utilities that refused to accept the principle of elasticity found that they ended up with enormous amounts of machinery capable of generating electricity but no market for it.

We have gone into the decade of the 1990s with surpluses of substantial amounts still remaining in some parts of the country.

We also saw, during the decade of the 1980s, the creation of new entities with a new name—"qualifying facilities" created under the National Energy Act,[2] which were small power producers and cogenerators from whom electricity was purchased by electric utilities on a mandatory basis. And we saw a strong ideological thrust to change the character of the electric utility industry.

During the Reagan Administration, ideas about competition, diversification, and deregulation were prevalent, and they were picked up in a

[2]Mr. Hobart was referring to the Public Utilities Regulatory Policies Act (P.L. 95-617).

very faddy way in many respects by those people who ran parts of the electric utility industry. Some of you may remember the phrases that popped into the lexicon of the electric utility industry. There were "gencos" and "discos" and "transcos." Now we hear of one of the individuals who perpetuated those phrases recently working for $1 a year as head of the power company that tried to do all those things. He found that the fads didn't work and he ultimately left.

We found out that a lot of other things didn't work out the way people anticipated, that the concept of deregulation for the electric utility industry wasn't quite what it was cracked up to be, and that you couldn't deal with that industry like you might deal with trucks and airlines.

Now we have come into the decade of the 1990s, and again we face a changing picture as far as the electric utility industry is concerned.

Much of the surplus in generating capacity has been sopped up, not just by sales to residential, commercial, and industrial customers within specified service areas, but by transactions that took place across a broad span of territory in an unaccustomed way. Large blocks of power are moving thousands of miles from one electric utility, through the service territories of others, and to an electric utility even farther away for ultimate use.

We now hear talk about what we are going to have to do in terms of providing new generation to take care of expanding load. And we have seen, in the past 2 years, load growth that exceeded 4 percent on a national basis, which has led some to believe that we may have underestimated what our future demand is going to be through the decade of the 1990s and into the next century.

But, simultaneously, we have seen a growing recognition that simply adding additional machines is not necessarily the best tactic in trying to ensure that customers have the energy services that they require. Out of the 1980s, and into the 1990s in a very prominent role, has come the concept of demand-side management as a way of dealing with what electric utility customers might need for their own demands.

And new concepts have come into being as to how we think about what the responsibilities of an electric utility are. These concepts are driven by a number of forces, some of which were mentioned by Dexter [Peach] and by Dan [Dreyfus]: our concern about oil imports, which, in the last year, constituted 40 percent of our domestic petroleum use; our growing awareness that we cannot endlessly inflict insults on the environment without paying the consequences and that the consequences can be severe and unacceptable; and the belief that we can use institutional processes to better achieve our aims in clearing out the functions of the electric utility industry.

I want to talk briefly in the time allotted to me about some particular aspects of these changes that I think are important to you and the work that you carry out through the General Accounting Office.

I think the first point to make about change and about the electric utility industry in the 1990s is that there must be an awareness of the importance of the electric utility industry to the economic well-being of the country in a variety of ways.

Our electric bill, as a country, comes to about $160 billion each year. Obviously, it doesn't arrive in a single tally. It is disseminated through individual bills, which arrive in your homes and at businesses and commercial enterprises all over the nation. But people pay these bills. And one of the things that we have also seen in the last 2-1/2 decades is that for many people, economic well-being has not been enhanced but has remained either stagnant or has actually fallen. It is a statistical fact that young families—particularly those with children—have actually lost purchasing power over the past 25 years. Even when we look at the population as a whole and when we take into account inflation, we find that there is a minimal increase in the purchasing power of Americans throughout the country. In fact, our standard of living, in effect, rose only about 1 percent per year during the period 1973 to 1987.

If we take into account that more women have come into the labor force during that period of time, we can see that, in a certain sense, we actually fell back, because now we have to have more bodies per family in the work force to maintain our standard of living.

One out of 18 Americans in the work force currently is a moonlighter—a person who has two jobs, presumably in order to make it economically or to have a standard of living that exceeds that which would be possible with a single job.

We also know that businesses and industries increasingly are taking into account the cost of electricity. It used to be considered a minor matter as a business expense, but it no longer is a minor matter for many energy intensive firms. In some service territories in this country, we have actually seen industries leave because they concluded that they could get a better deal on electricity someplace else, and that fact was important enough to them that they decided they would make a major effort to alter their electric bill. We have even seen, of course, industries leave the country. While they are not driven out by electric bills, that is one of the factors that can come into play.

We are also seeing in this country steady growth towards a more service-oriented economy. While manufacturing has advanced—it may have stabilized as an economic force in this country—it is also increasingly automated for reasons of flexibility and economics. Many of the industries or activities that we see developing economically in the United States are not based on the production of durable goods in the same fashion that they were in the past.

As our population ages and we see a diminution in the need to acquire some of the possessions of modern life, we may find that the durable goods business has changed significantly.

So economic well-being is clearly one of the factors that we have to take into account as we plot the public policies that are important to the electric utility industry.

The second fact that is increasingly important—and, again, it was referred to by Dexter [Peach]—is the belief that the environment must be better protected against the onslaughts of industrial production in various ways. You know, of course, that that is an important item as far as the Administration and the Congress are concerned, and we are seeing it tackled in the Clean Air Act reauthorization legislation that is now moving its way through the Congress. Acid rain was a part of that proposal—and remains so—and it is of great importance to electric utilities.

APPA, in 1984, endorsed the idea that a legislative proposal should deal with the acid rain problem. In the intervening period of time, we have tried to ensure that the proposal that was ultimately enacted would be efficient, effective, and equitable. We hope that will happen when the bill finally goes to the President.

But it is a fact that the public is prepared to pay additional cost to have these kinds of things taken care of. The question is: How do you work out the details and exactly what is that cost? That cost is not small. Acid rain cost estimates vary hugely in the debate that has been taking place in the Congress, but clearly a double-digit, multi-billion-dollar price tag will be applied to curing the acid rain problem over the next couple of decades.

We have seen in the area of the environment a switch in concepts that is important to electric utilities and to other industries, too. That is the idea that, while we can mitigate the adverse environmental impact of industrial production of various kinds, it is perhaps easier to stop the problem before it starts. In other words, rather than trying to cure the infection, it would be best to prevent it. The kind of "vaccinations" that the people are talking about now are of a type that say, "Look, we have to examine basic industrial processes and find out whether they can be utilized in an effective fashion to continue to provide a service, but simultaneously we must avoid particular environmental insults that we cannot accept."

One of the ways that people are increasingly thinking about doing this is to apply concepts of efficiency to the production of goods and services. We find that in the Congress, for instance, this is a much more acceptable way to look at the problem than efforts to impose draconian measures to mitigate, alter, or prohibit particular processes that are already under way.

For instance, in connection with concern about global warming, where the science remains somewhat uncertain, where the economic consequences of particular actions are very great, and where the United States, by itself, clearly cannot solve the problem, but somebody believes that something should be done, politicians tend to turn to efficiency. That is why we have seen considerable support in the Congress for things like more efficient ballasts for fluorescent lights, why we now have a law that relates to the efficiency of household appliances, and why there is current interest in home energy rating systems, which might be mandated by federal law.

We are also increasingly coming to the understanding—and this is true in the electric utility industry as well as other parts of society—that it may not be the best approach to patch up the systems that we have in order to make them more workable. It is a fact that the technologies and the techniques that we are aware of turn not just on scientific and engineering developments but have to relate to the machines and the methods that we need in order to arrive at a correct social result. That suggests that we need to determine the characteristics that we would like these pieces of equipment to have and the possibility of actually creating them to perform the functions that we know we will need in society.

Let me talk about a third factor that is also important in the electric utility industry: structure. We have heard a lot over the past 10 years about restructuring of the electric utility industry. It is useful to think for a moment about how we have looked at this industry in modern times in the United States.

In this country, the electric utility industry is a public business. It is a business affected by a continuing public interest. In the United States, the electric utility industry and individual utilities are either owned by the public and operated by citizens or controlled by the public through the process of regulation.

We saw in the 1980s suggestions like, "Why don't we make the electric utility industry into something that is more competitive and use the analogies that are common in other businesses?" Well, one of the facts which that concept ran up against, I think, was a failure to recognize some of the practical difficulties that exist in applying the competition concept, not the least of which is that, in modern times and with existing technologies, we have found that the most effective way of providing electricity is through designated service territories that give you an opportunity to utilize economies of scale. In recognition that a monopoly results and that electricity is essential for modern life, we have applied public direction in how that process is carried out.

We have talked over the past 10 years about different forums that might be utilized to help create more competition in the field of bulk public power supply and that might sharpen the wits and the pencils of electric utility executives and cause them to do a better job. One of the by-products of that thought has been the concept of independent power producers. We have such entities, of course, today. We had such entities a long time ago, too. They are not new in character in the kind of services they provide.

An independent power producer can be loosely described as an entity that builds facilities to produce electricity and then makes that electricity available to an electric utility that, in turn, retails the product to its own customers.

It is like a turnkey plant where the builder keeps the key and operates the plant instead of turning it over to the electric utility.

We have seen the idea of consolidation encouraged and attacked, and we have seen some large, private power companies consolidate in recent years. This is a continuation of a trend that goes all the way back to the 1920s. At one time there were more than 4,000 private power companies in this country; we now have about 270, and that number will probably diminish somewhat more.

We have seen a suggestion that we need to either junk or amend the Public Utilities Holding Company Act [of 1935] in order to arrive at a freer flowing electric utility industry. But we also know that such action can cause difficult problems because we have seen the subsidiaries of investor-owned electric utilities (IOUs) engaged in activities that have been clearly detrimental to the interests of consumers. To minimize protection may be going exactly the wrong way.

We have seen subsidiaries of IOUs selling power back to themselves at prices that include a profit as high as 70 percent. We have seen subsidiaries and parent companies acting at less than arm's length in negotiations, and their attorneys paid out of the same pocket. We have seen an effort by an IOU subsidiary to launder transactions so that the sales could be made through a subsidiary and the profits channeled to shareholders rather than to the benefit of rate payers. We have seen a state commission ask the Securities and Exchange Commission to pull back an exemption from the Public Utilities Holding Company Act because diversification endangered rate payers in that particular state.

So it is not clear that a correct course to follow is to weaken regulation when we can find abuses even under the existing system. Ultimately, utilities are going to have to bear the responsibility for supplying need, and we want to ensure that the public is properly protected when they do so.

"The approaches that electric utilities take to solve their problems will be different in the 1990s."

The approaches that electric utilities take to solve their problems will be different in the 1990s. "Least-cost" planning is a concept that is now widely accepted by state regulatory commissions and public power systems. It really means an opportunity to compare a spectrum of possibilities in trying to satisfy customer need: a spectrum that runs on one end from energy conservation and load management and related approaches up through the provision of customer-generation in the center—which can offset the need for additional capacity by an electric utility—and on to more conventional approaches in which the electric utility builds generating capacity for itself.

Application of this idea requires planning. However, this is not a great country for planning. Planning gets a bad rap. It sounds like somebody is going to tell you what to do, and Americans, in our cowboy economy in the past, have thought that's not good. If you are going to wear chaps, you ought to wear what color you want.

But we have to figure out some approach to these problems and have some continuity that we can sustain over a period of time if we are going to do the things that we say we want to do. So planning is increasingly going to become a part of what we see in the electric utility industry. It is going to be accompanied by more democratic decision-making.

We hear a lot about why it is important in Poland and Russia and Lithuania for people to have a voice in their own government, but I can tell you from local experience that the idea is alive in America, too. People want to be able to say something about the decisions that affect them, including how their electric bill comes out.

We are going to need expanded and more sophisticated risk assessment to determine what is really the problem and what is really the answer and what the relative values are of both problem and answer. You in this room and others are going to help define how we go about that task.

Dan [Dreyfus] talked about some of the fuels. We are going to use a variety of fuels. Some of the choices will be dictated by policy decisions that are not even made as of yet. But the electric utility industry's approach to this problem, I think, is the following: we face uncertainty, and we need flexibility in order to respond. So people look for a mix of fuels. The gas industry is not going to hold the electric utility industry hostage. We must have something else that we can rely on. We are going to use oil. We are going to use coal. It is hoped that nuclear energy will remain a viable option. We have opportunities to expand some of the renewable, also, plus such things as garbage incineration and cogeneration.

The last item I want to mention to you is the importance of electric transmission. Transmission lines carry electricity in large amounts from generating stations to delivery points, where it is stepped down and taken to households and businesses throughout a particular service area. Transmission is the key to control of electricity. If you do not have access to transmission lines, then you are restricted in your ability to bargain with potential suppliers. You may become the victim of a monopolist who can hold you at his mercy and actually cause you, in the worst situation, to go out of business because you cannot maintain competitive rates.

Transmission needs to be regulated in an effective way. We have two places where transmission is regulated—one is the state commissions, and the other is the Federal Energy Regulatory Commission (FERC). Both types of entities have a role to play. FERC has been somewhat reluctant to use its full powers in this arena. It is starting to employ them more fully in merger cases, where it is conditioning mergers with transmission requirements, but it has yet to steel its nerve and use all of its rate-making powers to do the things that it could do and that it probably should do. The states have dragged their heels, too. The states have possibilities that they haven't fully exercised because they are the authorities that allow the siting of transmission lines and they can condition the permissions that they grant.

The state of Wisconsin is an example of a state that has moved forward and said, "Look, we are going to have an integrated transmission system in this state because it makes sense economically and environmentally. We won't approve future actions by electric utilities unless they can show that they have taken part in that kind of a scheme."

We at APPA commend the Wisconsin approach and have talked about it with other state commissions. We hope that it will become a part of the future as far as transmission is concerned.

Amory B. Lovins
Rocky Mountain Institute

My thesis is that the amount of energy we will need is not fate but choice, and that this choice can be exercised with enormous flexibility.

We also know that it can be exercised in both directions, because in recent years we have had many experiences of deliberate increases in energy demand. For example, the rollback of the Corporate Average Fuel Economy (CAFE) standards, coupled with a 70-percent cutback in the print run of the Gas Mileage Guide[3] so two-thirds of new car buyers couldn't get one, resulted in 1986 in an immediate doubling of oil imports from the Persian Gulf. Or, on the electric side, the Electric Power Research Institute (EPRI) has estimated that, of the baseload electric savings to be achieved by utilities' demand-side programs for the rest of the century, approximately two-thirds will be wiped out again by utilities' power marketing programs. (In fact, sometimes it is the same utilities' power marketing programs.)

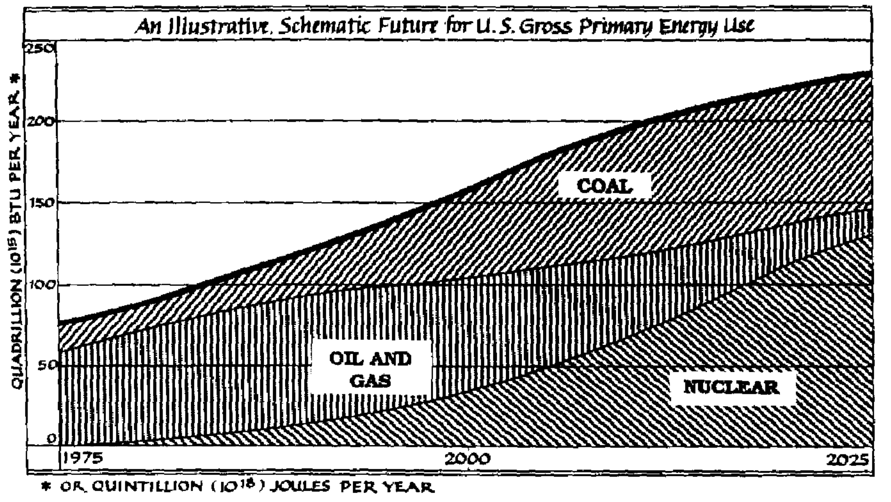
I'd like to talk about the flexibility we have to influence demand in the opposite direction by increasing energy productivity in a way that works better and costs less in delivering the same services—the same hot showers, cold beer, mobility, torque, and so on.

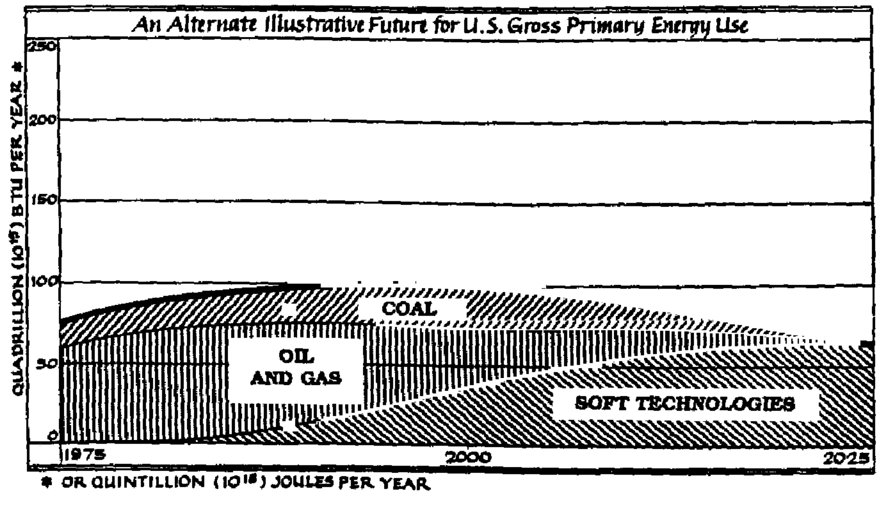
To put in long-term perspective how far we have come in achieving that already, some of you may recall a Foreign Affairs article in 1976 that looked at two ways the U.S. energy system could evolve over the next half-century or so.

Of course, what answer you get depends on what question you ask. If you think the problem is where to get more energy—more, of any kind, from any source, at any price—you end up with projections something like the upper graph in figure 1.1. There are still some people around who do projections of that kind. There are a lot of reasons it doesn't work: it is too expensive, too logistically difficult, too disagreeable.

[3]The Gas Mileage Guide is published annually by DOE as an aid to consumers considering the purchase of a new light vehicle. The guide estimates miles per gallon for each vehicle available in the new model year.

Figure 1.1: Schematic Alternative Futures for U.S. Gross Primary Energy Use, 1975-2025





Source: Amory B. Lovins. "Energy Strategy: The Road Not Taken?", Foreign Affairs, An American Quarterly Review, October 1976, pp. 68 and 77.

On the other hand, if you think the energy problem is where to get just the amount, type, scale, and source of energy that will provide each desired end-use service at least cost, then you might get something like the lower graph in figure 1.1. In that case, you'll notice that the fossil fuels, as they become costlier or less agreeable, are gradually replaced by appropriate renewables. But the important thing that happens before that is the stabilization and even reduction of energy use to provide the same growing volume of energy services from less primary energy as the losses in conversion, distribution, and use are gradually squeezed out.

As a reality check, I've placed two little marks on the lower graph to show what has actually happened in the first 13 years. The upper mark shows how much energy was actually demanded in 1988—11 to 12 percent below a total that had been greeted with some derision in 1976. The lower mark shows that renewables are also right on target at 11 or 12 percent of total supply, and the fastest growing part. The only thing growing faster is savings.

As a matter of fact, over the past decade or so, the United States has gotten over seven times as much new energy from savings as from all net increases in supply. Of the new supply, more came from renewables than from nonrenewables. In combination, mainly through savings, this has already cut the national energy bill by about $150 billion a year. If we were as efficient in aggregate as our major competitors, we would save another couple of hundred billion dollars a year; and if we got serious about choosing the best buys for the rest of the century, we'd save about enough to pay off the national debt.

"The energy now wasted . . . is still costing us about $300 billion a year . . ."

Yet, even though we have already saved $150 billion or so a year, we still have a long way to go. The energy now wasted—that is, energy that we use when we could use cheaper efficiency to do the same thing as well or better—is still costing us about $300 billion a year, or slightly more than the entire military budget of $10,000 a second.

As cited in figure 1.2, this has a serious impact on our competitiveness, not only directly, because we spend so much more of our wealth on energy than some other countries do, but especially indirectly, because that wasteful use leverages enormous investments in unnecessary energy supply. For example, we are still investing about $60 billion a year in expanding electric supply, half in direct investment and half in federal subsidy. That $60 billion a year happens to equal total investment in all durable-goods manufacturing industries. So if we only saved electricity fast enough to keep up with growth in service demand and retirement of existing plants, we'd be able to nearly double the capital pool available to keep those manufacturers competitive.

Figure 1.2: Energy Efficiency for Economic Competitiveness

The energy now wasted in the U.S. each year costs:

- **more than the $10,000-per-second military budget**
- **about twice as much as the Federal budget deficit.**

The U.S. spends 11-12% of its GNP on energy, compared with 5% for Japan; this difference gives typical Japanese exports an automatic ~5% cost advantage.

Huge investments in needless energy supply, rather than in modernizing industry, are an even bigger handicap. Expanding the U.S. electric system costs ~$60 billion a year in private investment plus federal subsidies -- about the same as <u>total</u> annual investment in all durable-goods manufacturing industries.

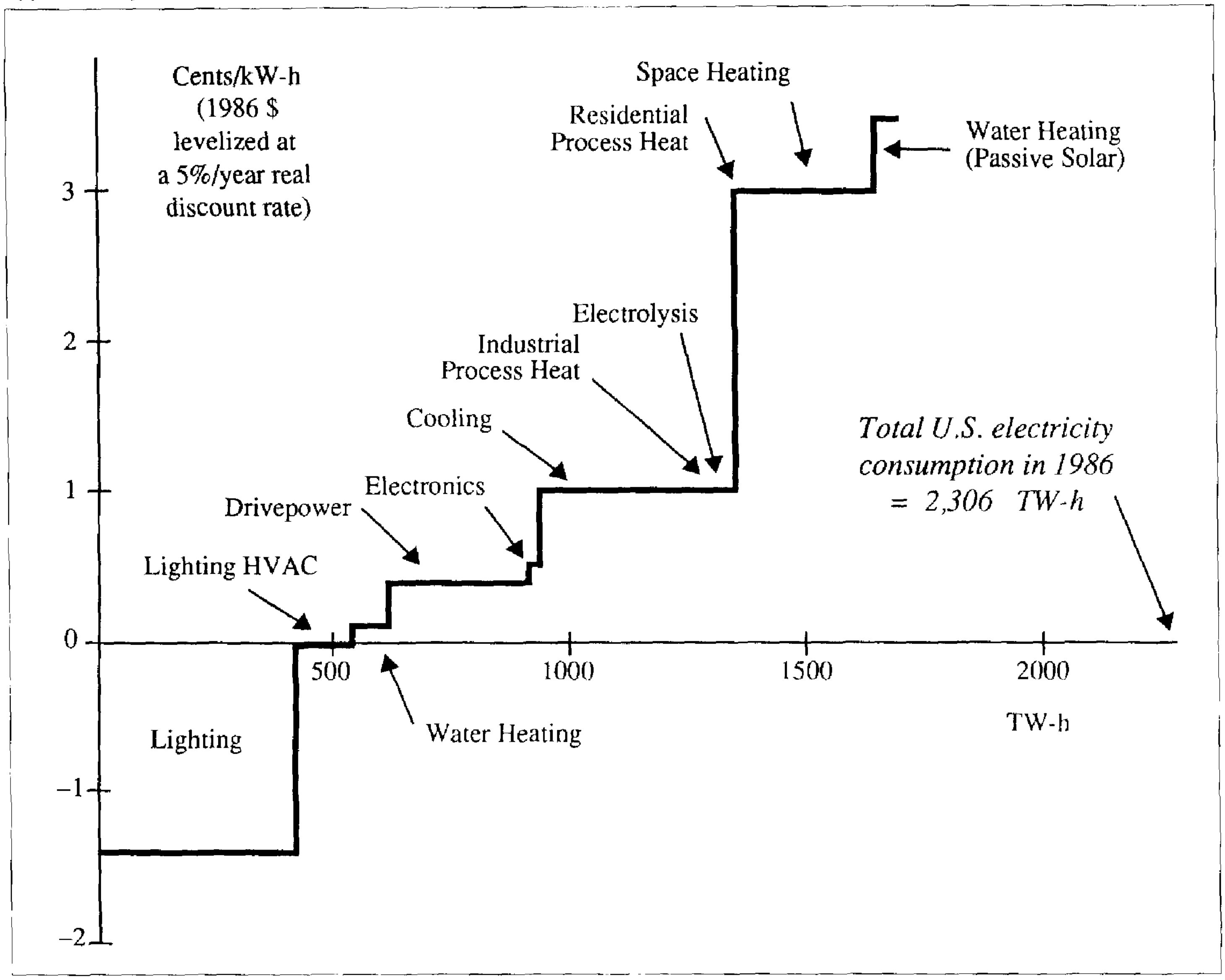
Japan is not only more energy-efficient than the U.S.; it is becoming even more efficient much faster. In four major industries, electric intensity per ton is falling in Japan but rising in the U.S. In 1986, a dollar of Japanese GNP used 36% less electricity than a dollar of American GNP. Official projections show this gap widening to 45% by 2000.

Source: Rocky Mountain Institute (RMI), DOE, International Energy Agency, and Alan Kahane (PG&E/Shell) data compiled by RMI

Not only that, but the efficiency levels that our competitors have reached, often better than ours, are rapidly moving away from us. There is a rapidly widening efficiency gap in electric intensity between the United States and, for example, Japan where in many major industries their electric use per ton is going down while ours is going up.

What is the potential, then, to do better with our energy productivity? And how much of that potential can we actually capture? Figure 1.3 is our best estimate of the supply curve for electric efficiency by retrofitting the existing U.S. capital stock completely, wherever the improved equipment fits, using the best technologies now on the market to provide unchanged or improved services. There are about 1,000 technologies shown here. The cost and performance data are measured. They are documented exhaustively in Competitek℠ reports, which are now used by 180-odd utilities, governments, and related organizations in 31 countries. So far these numbers are undisputed.

Figure 1.3: Preliminary Estimate of the Full Practical Potential for Retrofit Savings of U.S. Electricity at an Average Cost of Approximately .06 Cents/Kilowatt-Hour



Note: kW-h = kilowatt-hours; TW-h = terawatt-hours, or a billion kilowatt-hours.
Source: Rocky Mountain Institute analyses.

For convenience, I have lumped the technologies together into end-use categories, thus concealing a lot of fine structure. The vertical axis is 1986 cents per kilowatt-hour saved[4] . That is net societal internal cost, levelized at a 5-percent annual real discount rate. The reason the lighting package is shown as having a negative cost is that many lighting innovations actually last longer or you need less equipment to do the same thing, so they more than pay for themselves by avoided maintenance costs, thus making the electric savings better than free. For example, a quadrupled-efficiency light bulb with about a 13-fold increased life represents, in all its various shapes and sizes, about 50 gigawatts of U.S. efficiency potential.[5] By the way, over its life, one such bulb represents a "negaton" of carbon dioxide.[6] That is, it will keep a ton of carbon dioxide and about 20 pounds of sulfur dioxide out of the air. But far from costing extra, it generates tens of dollars of net wealth and defers hundreds of dollars of utility investment.

That's one of the costlier examples I could give of the general proposition that today it is generally cheaper to save fuel—especially by saving electricity—than to burn fuel, even at existing power plants. Therefore, the acid rain, global warming, urban smog, and other pollution you can avoid by substituting efficiency for fuel is achieved not at a cost but at a profit. So I think Larry [Hobart] is right in the magnitude he attached to acid-rain abatement costs, except he got the sign wrong. And [Chairman of the Council of Economic Advisors, Executive Office of the President] Michael Boskin does the same on global warming. There is no question that if you put on scrubbers it costs money, but it turns out you can more than pay for that, almost exactly reversing the cost and changing it into a virtually identical net saving, by paying for the cleanup through the operating cost saved by saving electricity more cheaply than you can make it.

In figure 1.3 the lighting package is advanced lamps, reflectors, ballasts, controls, and the like. There are eight things you can do to domestic water heating to save two-thirds of that load at a mill (1/10 cent) or two per kilowatt-hour. There are 35 things you can do to drive systems to save roughly half the motor energy, or a quarter of all the electricity in

[4]A kilowatt-hour is a unit of energy equal to the amount used if power is expended at the rate 1 kilowatt for 1 hour. It is enough to light a 100-watt light bulb for 10 hours, or to raise a ton over a thousand feet into the air, or to heat enough water for a shower a few minutes long.

[5]A gigawatt equals 1 billion watts of electricity, roughly the output of a large modern power station.

[6]That is, a ton of carbon dioxide not released by burning coal in a power plant, since three-fourths less electricity is used to produce the same amount of light.

the country. (The supply curve shows the minimum estimate, but we think it is actually about twice that big.) Then there are space and food cooling, space heating, and so on.

By the time you reach the top of the supply curve, the technical potential, I believe, is to save about three-quarters of all the electricity in the country, at a marginal cost comparable to or slightly greater than short-run marginal cost. But this would occur at much less than long-run marginal cost and at an average cost of about 6 mills per kilowatt-hour, which is several times cheaper than just running a coal or nuclear plant, even if building it cost nothing.

That sort of saving would be very profitable for a utility to give away, even if it had capacity coming out of its ears, because capacity is a sunk cost. But here you can still save marginal variable cost; that is, if it is cheaper to save electricity than to make it, then on the logic of economic dispatch, you should save it instead of making it, regardless of how much capacity you have. To be sure, your sales and revenues may then go down, but your costs will go down more; all that remains is for your regulatory commission to let you keep part of the savings as extra profit.

The National Association of Regulatory Utility Commissioners last November unanimously agreed to that sort of policy in principle, and also to decoupling utilities' profits from their sales.

Today, in 45 states, utilities are rewarded for selling more and penalized for selling less, but that is rapidly changing. Five states have already changed the rules, and 19 more are now doing so. I think we will rapidly see this sort of regulatory disincentive disappear in the next few years. That's starting to accelerate the already rapid change in utility culture.

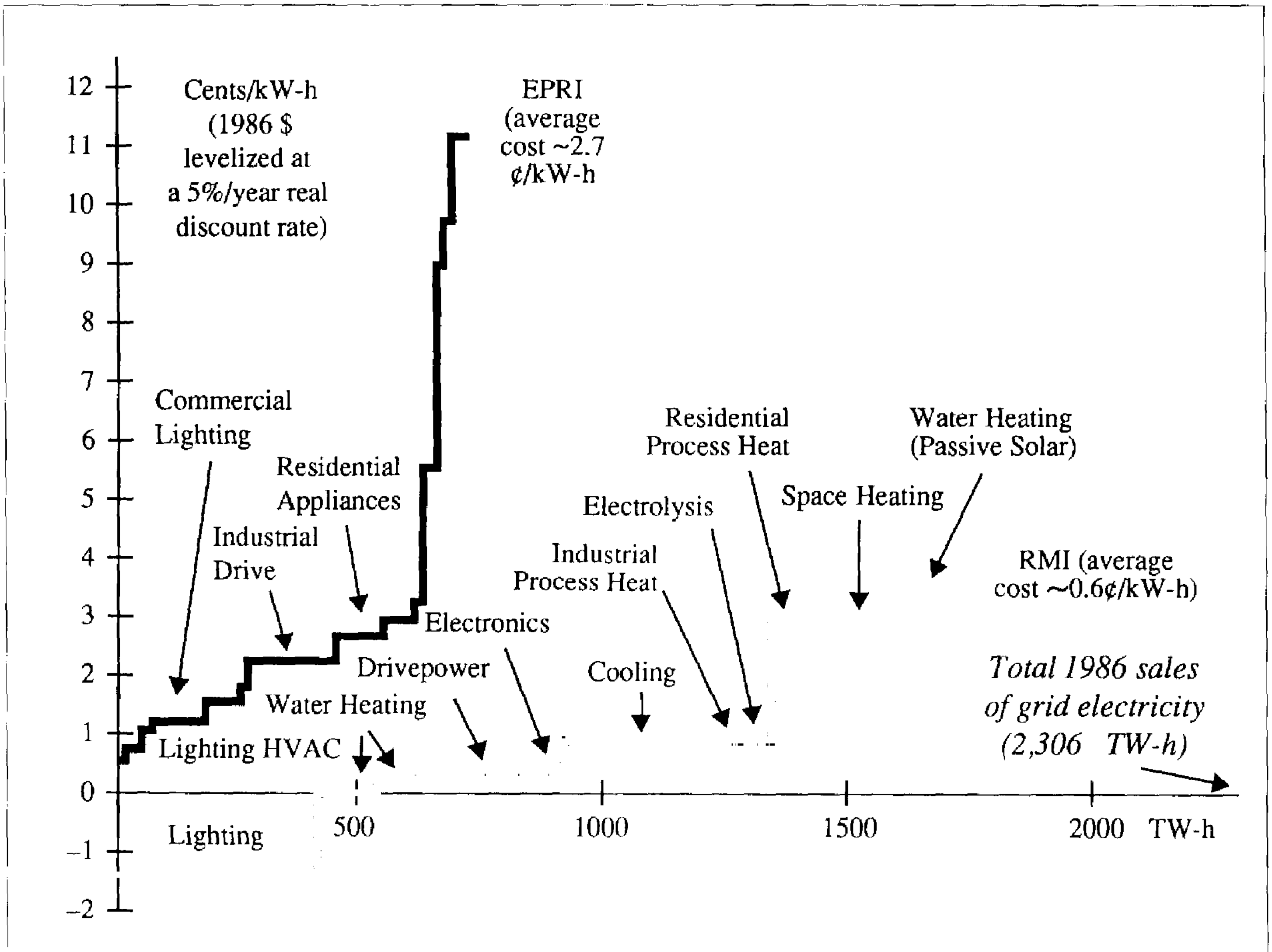
For comparison, EPRI's best estimate (see fig. 1.4) is that you can save, in technical potential, about 33 to 53 percent of U.S. electricity in the year 2000, compared with 1987 efficiency levels. EPRI places the average cost at several cents per kilowatt-hour. I think that there are four methodological and four substantive reasons for this difference.

The methodological differences are that

- EPRI shows potential savings to the year 2000 only, but RMI shows long-term saving potential, however long it takes to achieve;

- EPRI excludes, but RMI includes, the 9-15 percent savings that EPRI expects to occur by 2000 without additional effort;
- EPRI's curve falls near the low end of an uncertainty range spanning 20 percentage points, while RMI's curve is a central case; and
- EPRI doesn't, but RMI does, take credit for avoided lighting maintenance costs.

Figure 1.4: Comparison of Two Supply Curves for Potential Retrofit Savings of U.S. Electricity



Source: Rocky Mountain Institute

Much smaller substantive differences remain, for four reasons. One is that our [Rocky Mountain Institute's] analysis uses more modern technologies. That is important, because over the past 5 years the quantity of electricity you can save has roughly doubled and its real cost has fallen roughly threefold. So if you are even a few years out of date, it makes a big difference in the result.

Second, we are trying to characterize more fully what the technologies do. For example, out of the 15 known ways in which electronic ballasts save electricity, we are counting the 10 that have been quantified, not just the 2 that used to be counted.

Third, when you look at roughly 1,000 technologies instead of roughly 50, you pick up a lot of small terms that are collectively important because there are so many of them. This disaggregation roughly doubles the quantity of savings.

Fourth, when you do whole-system engineering with meticulous attention to detail, you find many synergisms between technologies that cut the total cost of the package by severalfold, because you get multiple benefits for a single expenditure. For example, in the case of drive power, you need to pay for only about 7 of the 35 measures; the other 28 are free by-products. That's why the whole package is so cheap.[7]

There are, in fact, many utilities saving large amounts of commercial and industrial electricity at total costs of about half a cent per kilowatt-hour. There are also quite a few existence proofs in which utilities are achieving or capturing 70-odd to 90-odd percent of important efficiency markets, chiefly difficult ones like residential shell improvements, in just 1 or 2 years through skillful marketing. So although this supply curve shows a technical potential that is analogous to proved mineral reserves, the production plan can in fact, for this resource, achieve quite high recovery fractions with techniques that are now known.

Those techniques have to overcome formidable barriers in the form of lack of information; lack of mature delivery infrastructure; and implicit discount rates typically 10 times lower for utilities than for their customers, thus diluting price signals roughly tenfold.

[7]Subsequent to the conference, Mr. Lovins added the following postscript to his remarks based on an article published in the September 1990 issue of Scientific American: "EPRI actually agrees, in our joint Scientific American article, that the package can save about half of motor energy at an average cost of 5 cents per kilowatt-hour, but shows in its supply curve a savings only a third that big and five times that costly."

That particular problem, the "payback gap," was traditionally overcome by utilities' providing not just information but also financing in the form of concessionary loans, gifts, rebates, and leases. Increasingly, however, although those methods are very successful, utilities are moving not just to market "negawatts," but to make markets in negawatts: that is, to make saved electricity into a fungible commodity subject to competitive bidding, arbitrage, derivative instruments, secondary markets, and all of the other attributes of copper, wheat, and sowbellies. (See fig. 1.5.)

Figure 1.5: Implementing Negawatts

OLD METHODS: finance or market negawatts

- Public information (exhortation and education)
- Targeted technical information (builders, designers)
- Low- or no-interest loans (usually for weatherization)
- Gifts ("full financing"--cheaper than loans)
- Rebates (targeted, or generic for <u>any</u> kW_p or kW-h)
  - To buyer, seller, other trade allies, combinations
  - Coupled with scrappage of old devices
  - For beating minimum equipment standards
- Equipment leasing (20¢/lamp-month...)
- Third-party investors and utility service companies

NEW METHODS: make a market in negawatts

- Competitive bidding processes
  - Industrial modernization grants
  - Generalized ("all-source") auctions
- Fungible savings (with transmission credit?)
  - Wheeling between customers, utilities, & nations
  - Arbitrage between cost of megawatts & negawatts
- Negawatt/megawatt spot, futures, & options markets
- Peak-load covenants traded in secondary markets
- Efficiency cross-marketing
  - By electric utilities
  - By gas utilities
- Performance-linked hookup fees for new buildings
- Targeted mass retrofits, esp. of commercial lighting

plus sales/profits decoupling, exemplary rewards,
and predictable cost recovery to utility
plus quality control, tariff reform, barrier removal.....

Source: Rocky Mountain Institute.

This is working remarkably well. We have at least eight states that run open auctions in which all ways to make or save electricity compete against each other and the utility takes the low bid. (That method, by the way, has also enabled Maine to increase its independent power production, chiefly from renewable sources, from 2 percent in 1984 to 30 percent in 1991.) Some 27 states have already run supply-side auctions and, on average, have been offered eight times as much as they wanted.

We already have deals in which one utility pays another to save electricity and sell it back to the first one. Utilities are considering schemes in which customers are rewarded for going bounty-hunting and saving other customers' electricity. We even have about a dozen utilities selling efficiency for fun and profit in the territories of other utilities, because efficiency is not subject to a franchise monopoly. You can even have gas utilities make a lot of money selling electric efficiency. We have seven states weighing "feebates"—that is, when you hook up a big new building to the grid, you either pay a fee or get a rebate, depending on how efficient it is. That rapidly affects how buildings are designed.

If you look at the whole range of ways in which utilities can meet marginal service demand, you find there are demand-side resources, of which I have only talked about end-use efficiency, but also load management, service substitution, and fuel-switching. There are grid improvements, such as better voltage regulation, reactive compensation, amorphous transformers, reconductoring, and theft reduction. And there are supply-side resources—bulk power transfers; extending the life, efficiency or availability of existing plants; or buying new capacity, which falls in a spectrum between relatively centralized and relatively dispersed.

Relatively dispersed sources are a very diverse menu. They are not just classical combustion turbines, but the advanced gas systems Dan [Dreyfus] mentioned and increasingly a wide range of renewables now competing on the grid.

In every competitive economy I know about, investment is shifting rapidly away from the centralized resources towards everything else: on the supply side, the renewables and advanced natural gas technologies; and above all, demand-side resources, because all of these resources are relatively small, fast, cheap, and modular, and that is the only kind of resource you can afford if you wish to minimize regret in times of rapid social and technical change.

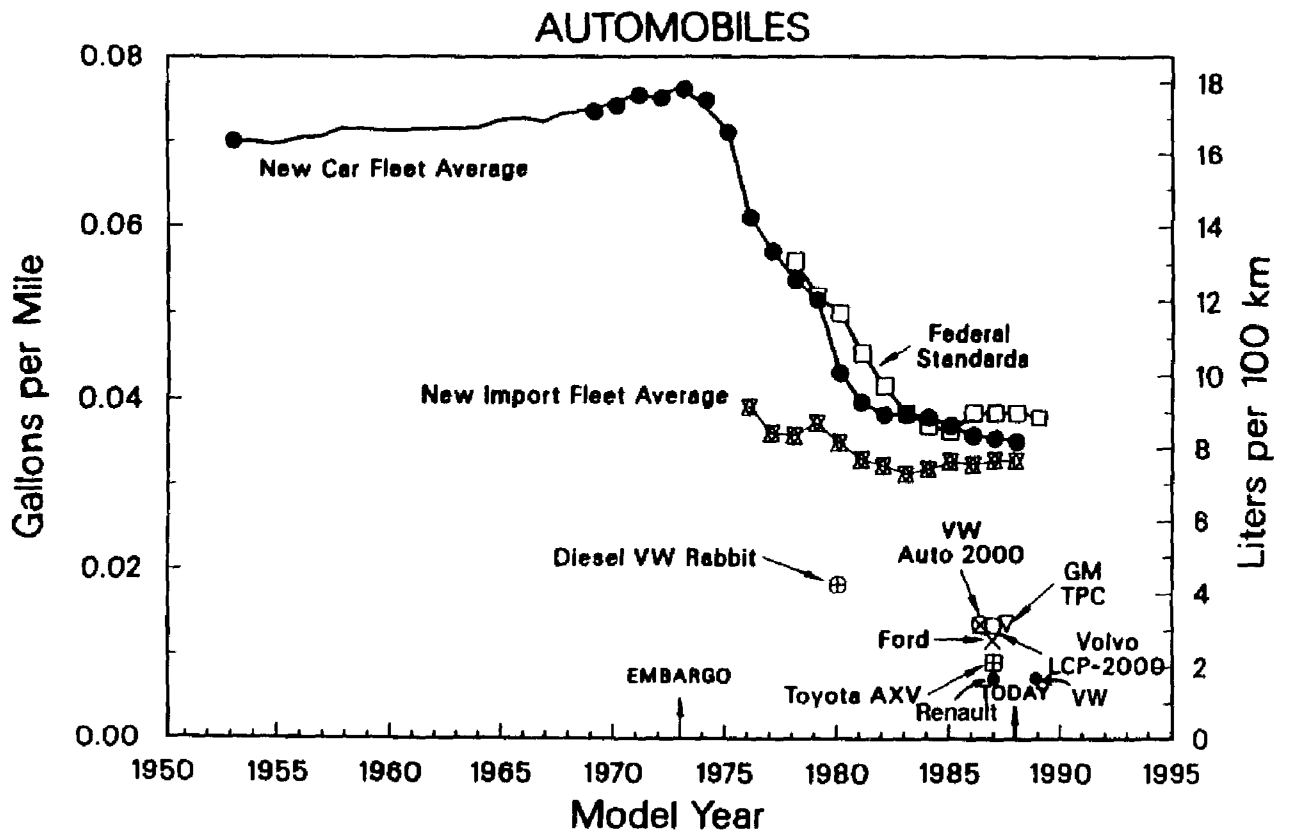
Very much the same picture applies to oil. A lot of people forget how successful we were in saving oil from 1977 to 1985, when we increased oil productivity at an average rate of 5 percent a year—four-fifths faster than necessary to keep up with both economic growth and declining domestic oil output. We did it largely with caulk guns, duct tape, plugged steam leaks, and a measly 5-mile-a-gallon improvement in the car fleet. Nothing fancy, but it was enough to cut imports in half.

By 1986, the energy saving—chiefly oil and gas—achieved since 1973 was, in effect, a new energy-producing sector two-fifths bigger than the entire domestic oil industry, which had taken a century to build.

Oil, however, had and has rising costs, falling output, and dwindling reserves; while efficiency has falling costs, rising output, and expanding reserves. It is fairly obvious which deserves the marginal dollars.

Now, if you try to estimate how much oil can be saved at what cost, you immediately notice that, although the oil intensity of U.S.-made cars has already fallen by half, the present fleet, at 20 miles a gallon, is a factor of 5 to 7 worse than at least 10 interesting prototype cars already demonstrated in the 67- to 138-mile-a-gallon range. (See fig. 1.6.)

Figure 1.6: Automobile Fuel Efficiency



Source: Compilation of Lawrence Berkeley Laboratory data, time-series data from DOE, and author's Renault and Volkswagen data.

In order to get those cars onto the market—that is, to get the manufacturers to overcome their retooling risk—it is important, as six states are now considering, to introduce a "feebate," since they are preempted from introducing standards. In the California case, there is a proposal to have a $200 fee or rebate on new cars for every mile per gallon by which they are under or over 28 miles per gallon.[8]

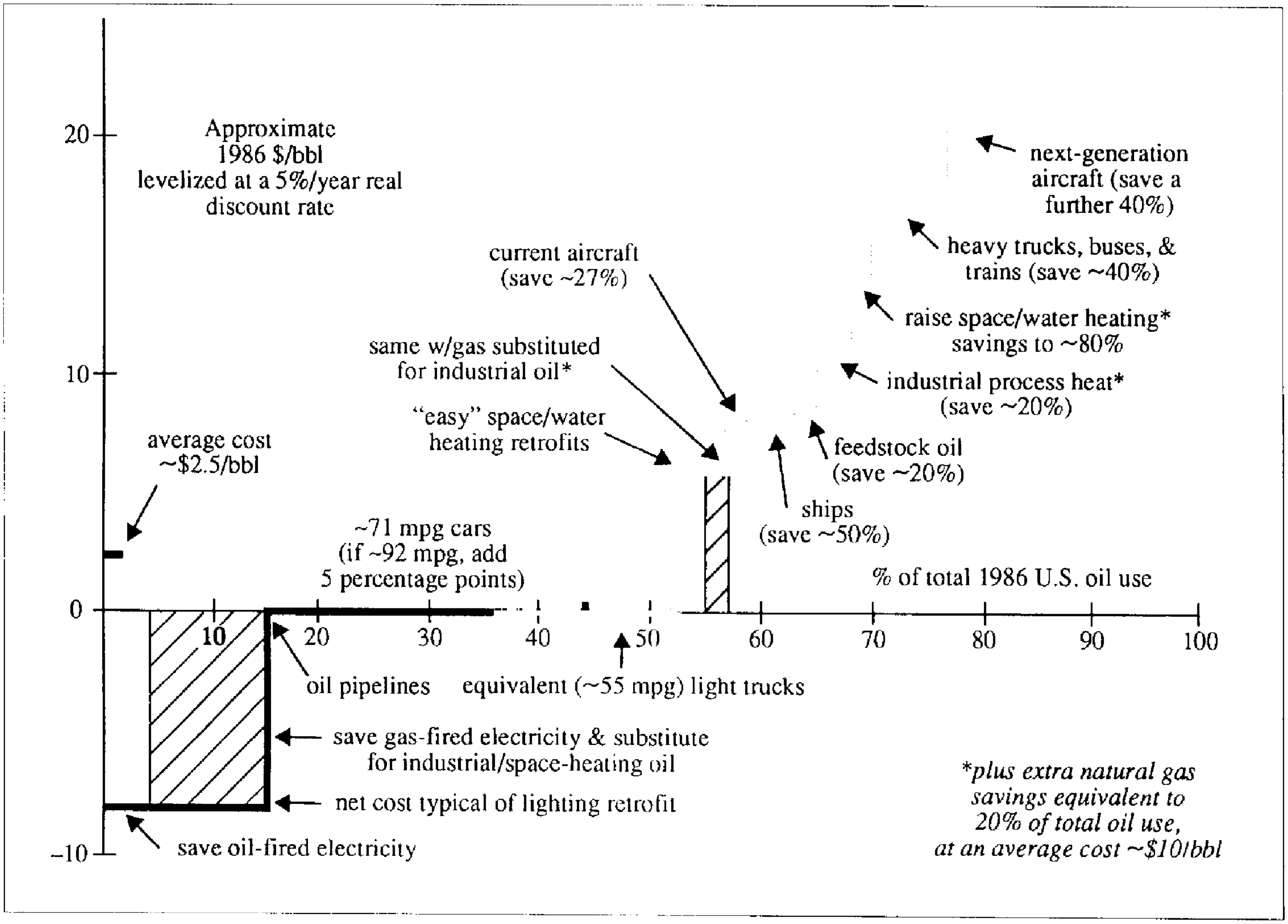
What I would like to do, of course, is base the rebates on the difference in efficiency between your new car and your old car which you scrap, so

[8]Subsequent to the conference, Mr. Lovins added the following postscript to his remarks: "The California legislature approved the proposal with slope reduced to $14/mile per gallon, in August 1990, by a 7 to 1 margin. Governor Deukmejian vetoed it. His successor is expected to sign a repassed version in early 1991."

that we have an incentive to get the dirty, polluting cars off the road as fast as possible: the least efficient ones; the ones that are driving import dependence, balance-of-trade deficits, global warming, acid rain, and urban smog. This scheme, by the way, is quite progressive. It would, for the first time, give low-income people an opportunity to buy cars that they could afford to run instead of trickling down the least efficient cars to the poorest people, who can't afford to run or replace them.

Figure 1.7 illustrates RMI's best estimate of the oil-saving potential using the best demonstrated technologies, about half of which are already on the market. The vertical axis is dollars per barrel in 1986. The horizontal axis is percentage of 1986 oil use. We start off by saving oil-fired and gas-fired electricity and then resubstituting the gas for other oil. You can actually save more than that total amount of electricity just on lighting retrofits, hence the negative cost. You would also save 1 percent on pipelines by not having to pump so much oil.

Figure 1.7: Technical Potential to Save U.S. Oil Consumption



Source: Rocky Mountain Institute.

For the superefficient cars and light trucks, I have conservatively just taken the less effective example of the two prototype cars that are said to cost nothing extra to make. You can actually do very much better than even the best prototype of 138 miles a gallon, but I'm not even counting any light-vehicle improvements with marginal costs greater than zero.

When you add in the well demonstrated space- and water-heating savings, process heat savings, and heavy transport savings (although these costs are a little fuzzy, they don't contribute a big quantity, so it doesn't much matter) you end up with a potential to save roughly four-fifths of U.S. oil consumption, at an average cost under $3 a barrel (cheaper than drilling for more), plus an additional 20 percent of leftover saved gas. The key to achieving that is, I think, the state-level (if not federal) feebates for efficient new cars and light trucks.

The results we have achieved so far are, in general, not the result of federal policy, with a few notable exceptions like the CAFE standards. For example, investment in energy research and development went, overwhelmingly—in the high 90s of percent—toward centralized electric supply, which is somewhere between 0 and 7 percent of the marginal energy problem we have.

In contrast, our marginal supply of energy services actually got its gains during the comparable period overwhelmingly from efficiency. (Actually, the renewable portion is understated severalfold because the Energy Information Administration doesn't count most of them.)

So the outcome was really the opposite of the federal priorities. And I think this reflects the long-standing practice that DOE's policy-making and actions have historically run inside-out. They ought to start by asking what specific end use is a given increment of energy needed for, and how much energy, of what type, at what scale, and from what source will meet that need in the cheapest way. If that result is unlikely to occur spontaneously because of some identifiable kind of market failure or technological gap, then what corrective actions, if any, are required and appropriate, and which of them is DOE uniquely suited or best suited to take? And are those actions, if any, hardware or policy actions?

Those questions, however, have not been asked until quite recently. The Department of Energy historically has started with existing or hoped-for bits of research, development, and demonstration that reflect "sweet technologies" that somebody wants to develop or build. Then DOE tries to find a possible use for the hardware. Lastly, belatedly, if the hardware turns out to work, DOE tries to figure out how to distort or coerce the marketplace into eating it. Historically, this has often failed, leaving the taxpayer holding a large bag, often because DOE considered neither the economic competitiveness nor the political impact of what it had developed.

Finally, I think we need to be cognizant of an historic pattern that threatens to repeat itself. We are often told nowadays that we need more balance: we need to buy both supply and efficiency. That is the sort of balance in the classic recipe for elephant or rabbit stew—one elephant, one rabbit. In practice, what we do might be thought of as the Chinese-restaurant-menu theory of energy policy, in which you select one item from column A, one from column B, and so on, until all important constituencies are satisfied.

The trouble with this approach is that you may get neither supply nor efficiency, because they compete for the same resources. Or even worse, you may get both and, as we have lately done several times, bankrupt the supply industries, because to pay for costly new supply ventures they need more demand, not less. If they get supply-side costs plus efficiency, they get the worst of both worlds, because they don't have the revenues to pay those costs.

However, I submit that the efficiency revolution is here. We are in an era of costly energy and relatively cheap efficiency. The customers will figure this out and want to buy less energy and more efficiency, and it is a good idea to sell customers what they want before someone else does. The only questions are who is going to sell the efficiency and whether the traditional energy suppliers want to choose participation in the efficiency revolution or obsolescence.

This is not a new choice. We have been here twice before. After two oil shocks, our government sought to boost supply while doing very little about demand. Supply expansions were directly subsidized by about $50 billion a year and probably still are subsidized by most of that amount. And in many other ways, the government sought to ease the path of supply.

The landscape is littered with the resulting wreckage of grandiose supply schemes that didn't happen, often because they were technically or politically infeasible, but most fundamentally because they couldn't compete in the market. What the market quietly did, almost unnoticed, was to produce a gush of efficiency and stick the supply industries with unsaleably costly surpluses. I think during the time horizon of the planning that Dexter [Peach] and his colleagues are working on, the real question is whether we are going to make the same mistake for a third time, as if, like an earlier ancien régime, we had learned nothing and forgotten nothing.

Douglas R. Bohi
Resources for the Future

The energy security issue has been around for a long time, but I think it would be useful to review some of the basic issues so that we know we are all talking about the same thing. After saying a few words about what I mean by the energy security problem, I will talk about the appropriate role for government action, the policy options that are available, and a number of uncertainties in the analysis of the energy security issue that GAO may wish to look into in the future. I'll conclude with a few comments about recent legislation regarding the size and use of the Strategic Petroleum Reserve (SPR).

To make it clear from the start, I don't view the energy security issue simply as one of dependence on imported energy. The facts do not support this simple view, since the United Kingdom experienced the deepest recession among industrial countries after the 1979 oil disruption even though it was approaching self-sufficiency, while Japan managed to avoid a recession in spite of almost total dependence on oil imports. The logic doesn't hold up either if one attributes the economic damage from a disruption to the adjustment problems created by changes in resource scarcity (i.e., changes in relative prices). As long as the economy remains open, the same adjustments are required of countries that are self-sufficient as those that are completely dependent on imports for their energy.

It is also useful to distinguish between a long-run and short-run energy security problem. The first involves a permanent increase in scarcity while the second involves a temporary increase in scarcity. The long-term policy problem is a matter of adjusting to the inevitable burden of higher resource costs and involves policy decisions such as government support of research and development to ease the adjustment costs. The short-term policy problem, which I will talk about here, is more a matter of avoiding unnecessary adjustment costs by temporarily alternating supply or demand, such as through the use of strategic storage.

The economic problem with temporary disruptions is one of dealing with the risks associated with an unexpected change in the price of energy. Insofar as the risks posed by a potential disruption are borne by the private sector, we should expect that private agents will adjust what they do in order to reduce potential costs or increase potential profits by being prepared. It can be shown that these responses will tend to alter the volume and timing of energy supply and demand in ways that will reduce the impact of a disruption. These private adjustments mean that the risks associated with a disruption do not alone justify government action. The rationale for government action should be based on some deficiency in private responses.

Care must be exercised in identifying government actions that are needed to achieve the same purpose as private actions. There is a point where additional preparations are not worth the cost; that is, where buying too much security can be just as wasteful as the losses that result from being unprepared. Since individuals will already strike a balance between the cost and expected benefits of being prepared, the government can reduce the risk of excess preparations by engaging in activities where it can be demonstrated that the private sector falls short.

Specifically, there is a rationale for government action if the private sector does not fully appreciate the prospects of a disruption, does not have the incentive to guard against the risks of a disruption, or does not take into account all of the costs of a disruption. These may be taken as necessary conditions for government intervention, while the stronger sufficient condition would require that the benefits of government actions exceed their costs.

Does the private sector have enough information? It may be argued that the private sector is inadequately informed because the benefits of information cannot be fully appropriated by those who bear the cost. Moreover, it may be argued that there are economies of scale in producing information that the government could exploit by centralizing the information collection effort. These arguments suggest that the government could provide better information more efficiently than the decentralized efforts of the private sector. There is, however, a serious risk with centralized information production when that information is inaccurate.

Will the private sector have the incentive to act on the information it does have? Concerns about government actions in an emergency are of importance in this regard. If the private sector believes that the government will step in and allocate energy supplies in a shortage, private incentives to prepare for a shortage are diluted. For example, if inventory holders might be barred from earning a capital gain during a shortage, the incentive to build precautionary inventories will be reduced. A similar effect is created when the government sells oil from the SPR, because those sales will reduce expected profits from private inventories and will reduce the incentive to hold private stocks. These examples illustrate how the government must take into account the effects of policy on private behavior, because those responses can mitigate the effectiveness of the policy.

A related problem of distorted incentives occurs in regulated industries, such as natural gas and electricity. Because prices and profits are fixed by regulation rather than by market forces, firms in these industries do not have the normal profit-making incentives to undertake investments in emergency preparedness. It is also unlikely that the regulatory bodies that have jurisdiction over these firms will ensure that the necessary actions will be undertaken or that they will provide the incentives for firms to do so. Moreover, state and local regulatory agencies are inherently provincial in their perspective and will tend to ignore the broader national perspective on the social costs of energy disruptions.

Regulation also reduces the degree of flexibility in the market to respond to an emergency. Electricity and natural gas prices cannot fluctuate in response to changes in market conditions, since they are established by regulatory rules and cannot change without a formal review. Yet changes in relative prices are the way in which markets reallocate supplies and demands to address shortages. Since gas and electricity prices are rigid, the burden of adjustment to energy disruptions will fall more heavily on nonregulated energy prices, particularly on petroleum.

Finally, are there economic costs of a disruption that are ignored by the private sector? In the literature on energy security one can find mention of lots of different kinds of possible disruption costs, but I will limit attention to two that I consider most plausible. The first concerns market power over the world price of oil, while the second refers to macroeconomic costs of energy price shocks.

The monopsony argument rests on the assumption that changes in oil demand, if large enough, will affect the world price and that the United States constitutes such a large share of the market that changes in U.S. imports can affect the world price. Private importers, acting alone, are not large enough to affect the price and will not take into account the effect of their purchases on the price. Yet, the nation as a whole has market power, and that power can be exercised by imposing a constraint on imports, such as a tariff or quota. The reduction in imports lowers the world price to buyers, and there, is in principle, an optimum tariff that transfers maximum rents from exporting to importing countries.

The same reasoning could be applied to any commodity imported by the United States, yet such a beggar-thy-neighbor approach to international trade can be highly destructive. To argue for oil import controls requires further justification that differentiates oil from other traded commodities. The usual justification is that exporters' rents are too high, because of the market power of the Organization of Petroleum Exporting Countries (OPEC), and that import controls would simply redistribute the rents closer to a competitive market outcome.

". . . the history of oil price behavior has never been adequately explained, yet it is an issue of great importance to energy security policy . . ."

It is arguable, however, whether OPEC has ever effectively exercised any market power. The price shocks of 1974 and 1979 are usually offered as evidence of OPEC market power, but hindsight suggests that the shortages in both periods were less a result of a decline in crude oil supplies than the effect of increases in stocks held by refiners, distributors, and customers. Furthermore, if OPEC has market power, why didn't OPEC use it to prevent the price decline in 1986 or to reverse the price decline after 1986? To me, the history of oil price behavior has never been adequately explained, yet it is an issue of great importance to energy security policy since the wisdom of any government action will depend upon assumptions about price behavior.

The macroeconomic cost argument rests on the assumption that prices and wages throughout the economy cannot adjust quickly to the large changes in energy prices, so that price shocks cause the economy to operate less efficiently and result in reduced employment and output. One example of this argument is that higher energy prices cause a reduction in the use of energy in producing other things, which in turn causes the productivity of labor to fall. A reduction in labor productivity means that wage bills have increased and that employers will seek to lower them. If wages can't fall (because of institutional constraints), the only option is to reduce employment. The consequence throughout the economy is a decline in employment and lower total production.

The macroeconomic cost argument is debatable as well. Evidence in support of the argument is provided by the widespread recessions that followed the two oil price shocks of the 1970s. Counter examples are provided by the absence of a recession in Japan in 1979 and 1980 and the absence of a widespread economic boom after the price decline in 1986. Also, a closer look at the recessions in the 1970s using disaggregated data by manufacturing industry in different countries fails to reveal a connection between energy intensity and employment or output behavior in those sectors, as one would expect if energy were responsible for the recessions. There is another explanation for the recessions that is consistent with the data: the recessions were provoked by contractionary monetary policies in most industrial countries (Japan is an exception). It is possible that the presumed macroeconomic costs of oil price shocks are really attributable to the misguided actions of monetary authorities. This issue deserves further study, since the presumption of high macro costs is essential to the rationale for the SPR.

What kinds of policies can the government pursue to avoid these macro costs, assuming that they are important? Two courses of action are possible: either act to prevent the price of oil from rising in the first place or act to moderate the effects of a higher energy price on the economy. There are few available policy options of the second kind, because there are no plausible ways of making wages and prices less rigid. One option is to adopt an expansionary monetary policy during a disruption, because this will create inflation and lower real wages in order to maintain employment. But even this recommendation is arguable for reasons that are beyond the scope of this paper.

To prevent the price of oil from rising to destructive levels, the government can reduce demand for imports either by imposing a tariff (or an equivalent quota) on imports or by releasing oil from the SPR. The tariff approach is obviously questionable because, while it may reduce the world price and redistribute rents to importing countries, it raises the domestic price even higher, with possibly greater macroeconomic dislocations. In contrast, the SPR can lower both world and domestic energy prices, but the cost of maintaining the SPR is large and is carried continuously whether there is an emergency or not. The difference in standby costs accounts for the preference of many International Energy Agency (IEA) countries to live up to their commitments through demand restraints rather than oil stockpiles.

Many studies have been conducted of the optimal size and use of the SPR, all of which compare the purported benefits of releasing oil in a disruption to the costs of building and maintaining the reserve. Measures of the benefits are all derived from assumptions about the effectiveness of the SPR in reducing the world price of oil and assumptions about the macroeconomic costs that are avoided by lowering the price. As I have indicated, both sets of assumptions are subject to considerable uncertainty.

The SPR may not be effective in lowering oil prices if past experience with inventory building and hoarding is repeated. In both 1974 and 1979, stocks held at refineries in Organization for Economic Cooperation and Development (OECD) countries (the only official inventory data) increased by hundreds of millions of barrels in just a few months. Anecdotal information indicates that stocks held by jobbers, shippers, distributors, and customers also increased above normal levels. These kinds of responses mean that the flow of oil into private storage can easily swamp any contribution from the SPR and that the effectiveness of the SPR in controlling prices may be determined more by moderating the actions of risk-adverse suppliers and consumers than by replacing a reduction in the flow of crude oil coming into the market.

However, changes in the structure of the oil market since 1980 imply that inventory behavior in future disruptions is likely to differ from that of the past. The increase in spot market activity, the decline in bilateral trading relationships, and the emergence of futures markets will affect the way that the world oil price behaves in future disruptions. This is another area where more research is required.

Concerns about the effect of the SPR on private expectations serve to increase the importance of international cooperation in energy policy. The reactions of other governments during a disruption can negate or reinforce the effectiveness of the SPR. This interdependence is well accepted by the members of the IEA, though perhaps not with the sense of importance necessary to lead to effective cooperation. The essence of the IEA agreement is the commitment by member countries to reduce import demand by either constraining consumption or releasing stocks. The United States has expressed regret that several countries have chosen the demand-reduction option, in part because of skepticism that effective actions such as import controls are costly (as indicated above), and hence may be compromised at a critical time.

To avoid the "free riding" problem, in which concerns that some countries will fail to uphold their obligations cause all countries to act the same way, each country must provide meaningful assurances to the others that the agreement will be honored. Stockbuilding in advance of a disruption, because it is a positive and expensive action, gives other countries the assurance that the commitment will be honored, while a promise to constrain demand does not. This asymmetry must be corrected in order for all parties to regard the agreement as a serious commitment that they all will honor.

I'll close with a few comments about recent congressional debate on the SPR: whether the SPR should be increased to 1 billion barrels, whether there is a need for a refined products inventory, and whether the SPR should be used in cases of regional shortages or other minor disruptions.

The need for a larger SPR depends on the presumed damage that energy price shocks impose on the economy; I do not believe that this linkage has been clearly established. If and when this linkage becomes established, the question remains whether a larger SPR is cost-effective or whether the United States ought to pursue a more effective form of international cooperation.

I see no significant benefits to be gained from building a refined products inventory, only additional costs. For disruptions in crude oil supply, crude oil and product inventories will work as substitutes for each other in moderating product prices, so one ought to choose the cheapest alternative. On the basis of both commodity costs and storage costs, crude oil inventories are clearly cheaper than product inventories. A product inventory can be useful for moderating a disruption that occurs at the product end of the supply chain. The question is whether this kind of a disruption is plausible enough to warrant government investment in product reserves. At present, it is difficult to imagine an interruption of world refinery capacity, or of product distribution facilities, that is large enough to seriously affect world product prices. As long as capacity is located largely in consuming countries, or at least outside of the Middle East and similarly volatile areas, the expected benefits of product reserves are small

Finally, I oppose the idea of using the SPR to stabilize consumer prices during minor disruptions. To smooth out minor price fluctuations amounts to an income redistribution policy that transfers income from taxpayers to specific oil consumers with adverse efficiency consequences for the oil market. The efficiency losses would occur because the normal market incentives to invest in private storage and fuel-switching capability would be destroyed and because the apparent price of oil (including price risk) would be artificially below the true cost of oil to society. Unlike cases where the SPR is used for major disruptions, there are no efficiency gains from a price-smoothing policy. One is prompted to ask why oil differs so much from other commodities that the government would contemplate sacrificing the efficiency gains of market-determined pricing for questionable income transfer benefits.

Panel 2: Energy and the Environment

Michael T. Woo

Committee on Energy and Commerce Staff, U.S. House of Representatives

I was asked to discuss some of the energy issues related to the pending Clean Air Act amendments and potential areas where GAO may be asked to provide assistance. In general, GAO is going to have a lot to do when we pass the Clean Air Act, with the fundamental question being: how is it working? We are about to enact probably the largest piece of environmental legislation heretofore enacted—not necessarily in its general sweep but in its attention to detail over a wide range of issues.

At least within the context of the political debate, the various sides are very far apart in their claims about what the effect of the legislation is going to be. So when we actually pass legislation—I very much anticipate that we will pass it this year—I think there will be a lot of questions about the legislation's actual impact. For example, what is the environmental impact of the legislation? Will the claims of the amount of reductions in acid rain, chlorofluorocarbons, ozone-forming compounds, and air toxic emissions actually be achieved? What is the cost?

Cost estimates for the various Clean Air proposals range widely. Some in the environmental community believe that there are going to be net positive benefits from cleaning the air, particularly if you include the health costs that are foregone as a result of having cleaner air. The business community estimates hundreds of billions of dollars of cost. That is a pretty wide range of cost; and depending on which side of that range is realized, it could have pretty profound effects.

Besides the cost, another concern is how technically feasible some of these new proposals are. One of the basic debates involved with many individual provisions is the following: Should the regulations be "technology forcing"? The goals and the standards may not be technologically feasible today, but they may be 5 or 10 years from now. Should we establish standards that force technology? On the one hand, the argument is that we should pursue legislation to force technology that may not currently exist. The other side of the argument is that we cannot force technology, and the Congress is asking us to do things that cannot be done.

So I think, in those general areas, a lot of work needs to be done.

Let me pick a couple of more specific areas. In the acid rain area, the President came up with the very original concept of using market-based incentives [the allowance trading system] to reduce the cost of significant sulfur dioxide reduction. However, there are many, many questions about whether that system, since it is basically the first of its kind of

". . . GAO is going to have a lot to do when we pass the Clean Air Act, with the fundamental question being: how is it working?"

this magnitude, is going to work—particularly when you consider the difficulty of trying to impose a market regime on the electric utility industry, which is a state-regulated, vertically integrated monopoly—and whether those two concepts can be made to operate together. Under this proposal, which was included in both the House and Senate versions of the bill, an allowance would authorize a utility to emit one ton of sulfur dioxide and could be sold by one utility to another.

Many questions exist about the workability of the allowance trading system; whether the system will achieve the benefits that are claimed for it; and, in fact, whether the system, as a whole, will actually work.

Because there are certain targeted deadlines for the allowance trading system, such as phase I, which goes into effect in the House bill in 1996, and phase II, which goes into effect in the House bill in the year 2000—another issue is whether the necessary preparatory work to achieve the deadlines will occur prior to those dates. In addition, we will need to monitor what is actually happening and if utilities are moving to comply. Whether they are complying or not is going to be a question.

Also, given the interplay of some of the reliability and structure issues with which the electric utility industry is now grappling—in terms of the availability of generation and potential rolling brownouts or blackouts—how does that fit with this fundamentally different regime that is to be overlaid on the electric utility industry?

Similar questions, as well as many concerning alternative fuels, are strewn throughout this bill. Since Roberta Nichols of Ford will address alternative fuels, I won't talk about them specifically. But one area which I can't help talking about is reformulated gasoline.

Reformulated gasoline probably has—at least of the issues I am involved in—the widest difference between the claims of the two sides. The environmental side claims that it is going to cost only 1 or 2 cents a gallon, that a lot of the companies are already adopting reformulated gasoline, and that the ability already exists to put in a few additives and handle the volatile organic compound reductions and the hazardous material reductions relatively easily. The other side—that is, some of the refiners—is saying it will be impossible to implement wide-scale use of this fuel. They suggest that what may occur is having no gasoline in the areas where reformulated gasoline will be required because it will require a complete reconfiguration of the refineries. They also argue that this reconfiguration would require permits, which we also address in the legislation, and that obtaining those permits will push the ability to comply way beyond the deadlines in the legislation.

Basically, the sanctions in the legislation specify that if the refiners cannot produce reformulated gasoline that fits the standards, then they cannot sell gasoline in that area. And, as they say, we will not sell illegal gasoline. So if there is no gasoline, there is no gasoline.

Thus, there are very, very wide claims. The cost estimates vary, as I said, from 1 or 2 or 3 cents per gallon to 20 or 30 or 40 or 50 cents, to the extent that there actually turn out to be shortages.

There is a wide range of issues. I think GAO is going to have a lot to look at.

Roberta J. Nichols
Ford Motor Company

I appreciate this opportunity to discuss some of the work that Ford Motor Company has been doing in the area of alternative fuels for the last 10 years or so. I will also try to project somewhat into the future how this fits in with what is going on currently with the Clean Air Act and future energy and environmental requirements.

Why alternative fuels? Although I have been asked to address which ones, first of all we have to ask ourselves, "why any change at all?"

We began this work in response to the energy crisis of the 1970s, realizing that if we were going to stay in the transportation business we had better think about alternative sources of energy for personal mobility. We still believe that this is a very necessary thing to do for the long term. Energy is still the primary long-term reason. In the process of doing this work, however, and putting some demonstration units out in the field and interacting with some regulatory agencies, a lot of people—including ourselves—began to realize that there was also the potential for improvement in air quality with many of the alternative sources of energy.

Fuels of the future are in two primary categories—gaseous fuels and liquid fuels. Methane (natural gas) and propane (liquefied petroleum gas) are the two types of gaseous fuels. Liquid fuels are of four types: reformulated gasoline and diesel, methanol, ethanol, and oil shale and coal-derived hydrocarbons.

A year or so ago when reformulated gasoline was announced, because I have been very active in the alternative fuels field, I got a lot of questions from interviewers about reformulated gasoline—what did I think of it? I said, "I love it. Where has it been?"

If the promise of reformulated gasoline does come forth and it doesn't cost a fortune, I can feel very good that reformulated fuel or reformulated gasoline may have resulted from looking at all of these other alternatives. People began to realize that you could change the character of the fuel and do something to clean up the environment.

Liquefied Petroleum Gas, or Propane

Ford has had a very active program; figure 2.1 summarizes what we have been doing.

Figure 2.1: General Status of Ford's Alternative Fuels Programs

. LIQUEFIED PETROLEUM GAS (LPG)
- Medium and Light-Duty Trucks in U.S.
- Passenger Car Production 1982-84 in U.S.
- Dealer Conversions in Europe/New Zealand

. NATURAL GAS
- Liquefied and Compressed NG Prototypes Built
- 27 Ranger Trucks in Field since April 1984

. ETHANOL (Brazil)
- 95% of Passenger Car Sales (was 99%)
- 85% of Truck Sales
- Engineering Support by Research Staff

. METHANOL
- 870 Vehicles in the Field (240 FFV)
- Focus is on Flexible Fuel Vehicle (FFV) Today

Source: Ford Motor Company.

We still produce a medium-duty truck that operates on propane, or liquefied petroleum gas (LPG). We have what we call a "prep package" for the light-duty truck—a 4.9 liter engine. We also had a production passenger car in 1982 through 1984, but we had to give up that production program because our sales were less than vigorous. About the time we really got going with that, the price advantage of propane disappeared because crude oil and gasoline prices dropped. So the cost of all this has a very big influence on the marketplace—not a new statement to any of you, I'm sure.

Natural Gas

We also see natural gas as a potential fuel of the future. We've done quite a bit of prototype work with a natural gas fuel. We have built some compressed natural gas vehicles and liquefied natural gas vehicles. We actually put a fleet of 27 Ranger trucks out into the field in 1984, and they ran for 5 years. In fact, one of them was down here in the Washington area. They did very well. I'll tell you a little bit more about some of the advantages and disadvantages of all of these fuels as we go along.

Ethanol

We have had a lot of experience with ethanol in Ford of Brazil. The technical aspects of that program have been a huge success. From a supply and demand standpoint, the program has been a disaster. It is a very long, complicated story, but I will try to give you an idea of what has happened in the last 3 years or so.

The Brazilian government has controlled the production of the fuel, which is a companion to the sugar industry. For the last 3 years, the amount of fuel that the industry was told to produce was held steady, but car sales continued to go up. So the car population using ethanol continued to rise, and you could see very clearly that the whole situation was on a collision course. Indeed, there is now a severe shortage of ethanol in Brazil because of this.

So ethanol vehicle sales are now in the cellar—down to about 13 percent of the total—when at one point they were 99 percent of the total, and not that many years ago. It is a prime example of what government intervention in a program like this can do for the marketplace.

Methanol

Most of Ford's experience with methanol has been here in North America. We have had, and do have, almost 870 methanol vehicles out in the field. Our early experience with methanol was with dedicated vehicles and the problems associated with them. No matter how we looked at bringing vehicles and infrastructure for refueling into the marketplace at the same time, it didn't appear possible. So today our focus is on the flexible fuel vehicle.

Methanol fleets in the field are shown in figure 2.2. I mentioned that the early ones were dedicated, primarily out in California. There were only 18 refueling stations in all of California for over 540 vehicles. We gave a lot of drivers a high level of anxiety wondering if they were going to find another refueling station. We also realized, based on this experience—and so did the government agencies involved in this program—that the only way you could bring a new fuel into the marketplace in an orderly fashion without major costs and supply disruption was to have a vehicle and engine that could operate on both the old fuel and the new fuel.

Figure 2.2: Ford's Methanol Fleets in the Field

870 VEHICLES / OVER 24 MILLION MILES

- **1981 40-CAR FLEET, CARB. ESCORTS (1)**
  - **OPERATED IN LA COUNTY**
- **1983 582-CAR FLEET, CARB. ESCORTS (1)**
  - **BUILT ON PRODUCTION LINE. 500 OPERATED IN CALIFORNIA.**
- **1983/84 8-CAR FLEET, EFI ESCORTS**
  - **5% CITY FE IMPROVEMENT AT .4 NOx**
- **1986/87 30-CAR FLEET, FFV CROWN VICTORIAS**
- **1989 210-CAR FLEET, FFV CROWN VICTORIAS**

(1) MANY VEHICLES ATTAINED OVER 100,000 MILES

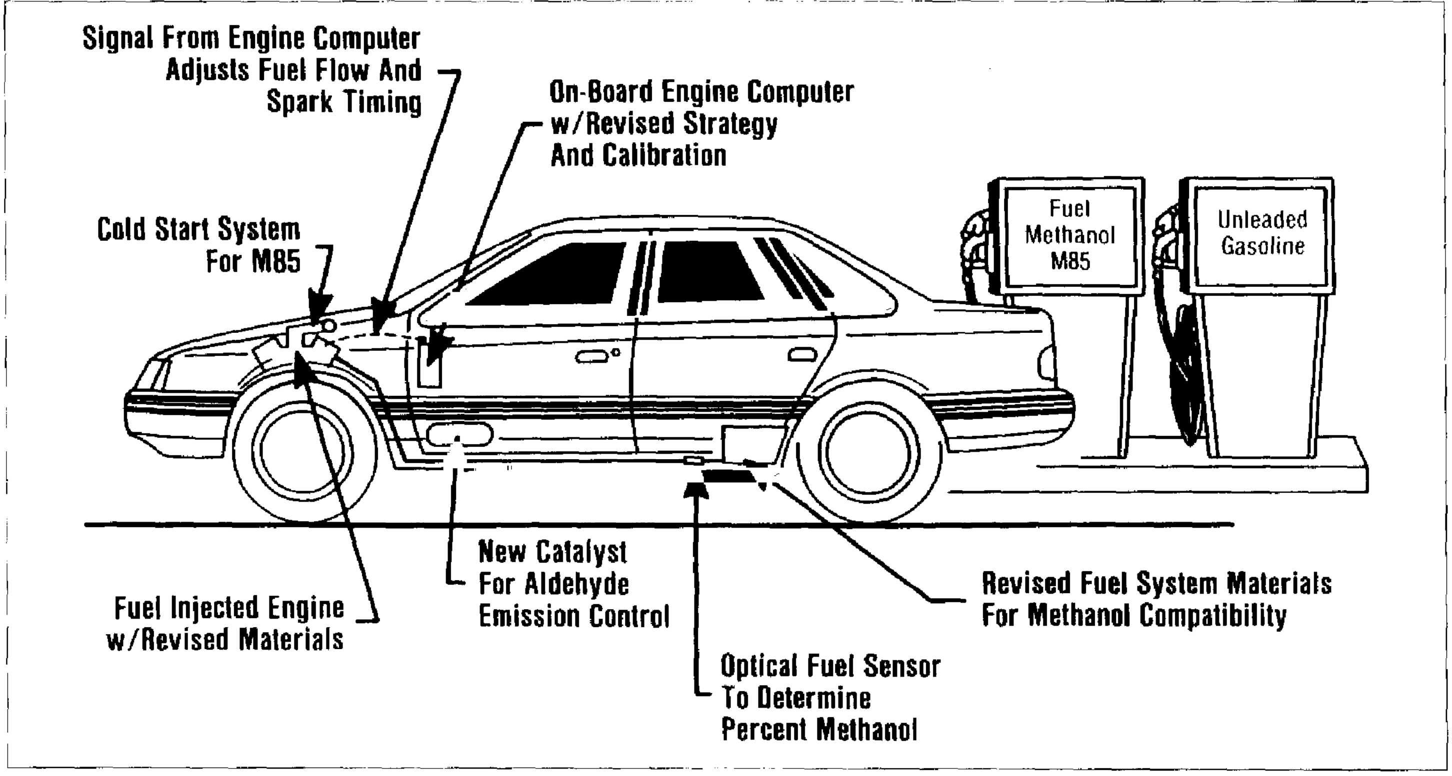
Note: EFI = electronic fuel injection; FE = fuel vehicle economy; FFV = flexible fuel vehicle.
Source: Ford Motor Company

Flexible Fuel Vehicle

High volumes of vehicle sales are required in order for vehicles to cost anywhere near what the consumer wants to spend. In addition, the infrastructure for refueling must gradually build up in response to the vehicle. That is the concept of the flexible fuel vehicle.

Figure 2.3 shows the advantages of the flexible fuel vehicle. One of the attributes of the flexible fuel vehicle that runs on methanol or gasoline or any random mixture, when it is operating on 85-percent methanol/15-percent gasoline, is a performance increase. We hope that this is one of the incentives for the consumer to purchase this vehicle. If methanol then starts to appear at his neighborhood gas station, he may experience the methanol, discover that he has more rapid acceleration and higher performance, and want to continue buying it.

Figure 2.3: Ford's Flexible Fuel Vehicle



Source: Ford Motor Company

Reduction of Exhaust Emissions

What have we done so far? In light-duty vehicles we have reduced hydrocarbon and carbon monoxide emissions by 96 percent and oxides of nitrogen emissions by 76 percent from pre-emission control levels. But we have not achieved compliance with the ozone air quality standards. That has been the big, elusive air quality standard, and the primary contributors to that are a combination of the hydrocarbons in the atmosphere, as well as the oxides of nitrogen.

Figure 2.4 projects reductions of the hydrocarbon inventory in the atmosphere. The first one—vehicle miles traveled—is a negative. Vehicle miles traveled continues to go up, which offsets some of the gains that we are making in the technology and improvement in emission control.

Figure 2.4: Potential Hydrocarbon Reductions From Mobile Related Strategies

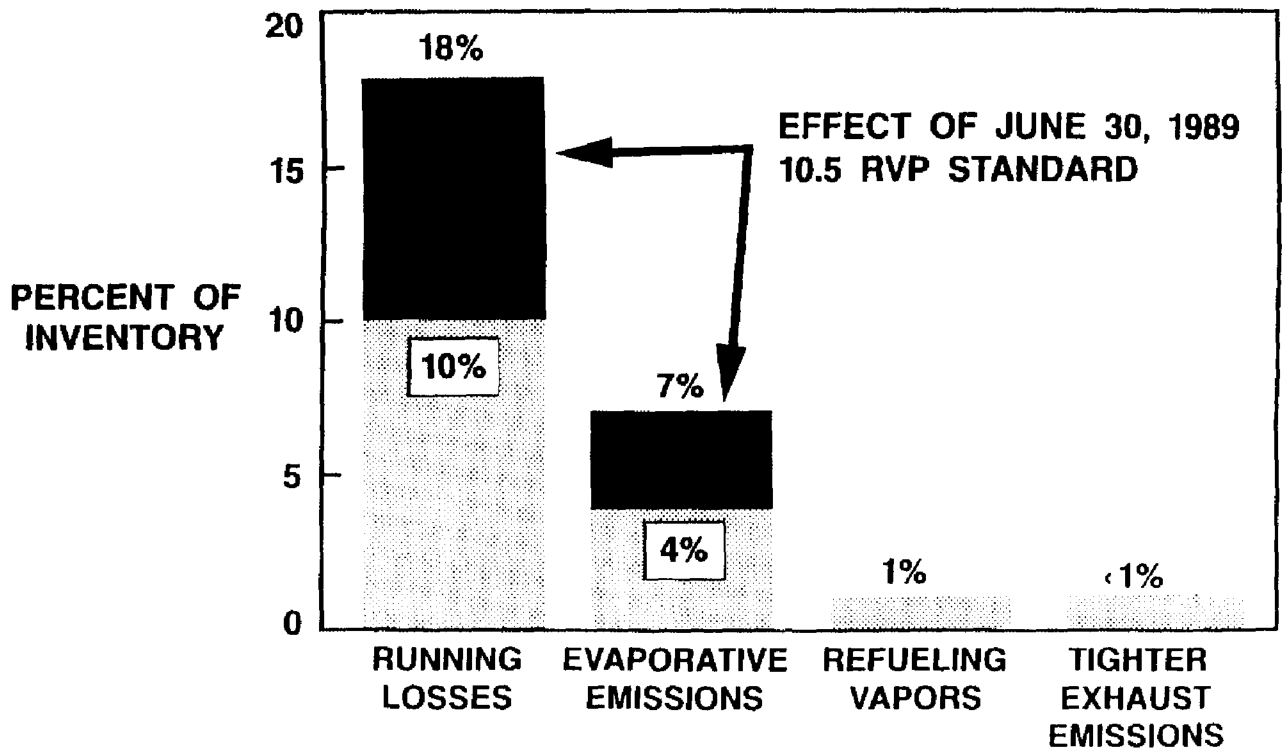
■ VMT growth	- 5%
■ Fleet Turnover	25%
■ Gasoline volatility	25%
■ Transportation Control Measures, gas rationing	10%
■ Enhanced I/M	2%
■ Refueling Vapors	1%
■ Tighter Tailpipe Standards	< 1%

Note: VMT = vehicle miles traveled; I/M = inspection and maintenance.
Source: Ford Motor Company.

The energy supply and demand panel discussed the price of energy. I have had a lot of discussions—so have others—about what kind of price increase it would take in the very cheap energy that the United States presently enjoys in order to make vehicle miles traveled go the other way. It would probably be a big price increase before it would change our lifestyles.

As figure 2.5 shows, regulations adopted in 1989 on the maximum volatility of gasoline have already reduced hydrocarbon inventories, so we are supportive of the kinds of actions I referred to previously. Evaporative emission controls and running losses have much bigger opportunities than tailpipe emissions.

Figure 2.5: Potential Ambient Hydrocarbon Reductions



Note: RVP = Reid vapor pressure.
Source: EPA.

Character of Exhaust Emissions

We have all been concentrating on tailpipe emissions, but today the next significant opportunity is in the character of the emission coming out of the tailpipe. Figure 2.6 shows why that is true. In fact, the same thinking applies to reformulated gasoline.

Figure 2.6: Photochemical Reactivity of Organic Compounds

Rate Constants for Reaction with Hydroxyl Radical

Compound	k x 10(-4) (1/ppm)(1/min)
Trans-2-Butene	10.5
1,2,4-Trimethyl Benzene	4.9
m-Xylene	3.4
Propionaldehyde	2.2
Acetaldehyde	2.2
Propene	2.1
Formaldehyde	2.1
Ethylene	0.45
n-Butane	0.35
Propane	0.25
METHANOL	0.148
Ethane	0.045
Acetylene	0.022
Carbon Monoxide	0.021
Methane	0.0012

Source: Ford Motor Company

Some of the typical bad actors of gasoline are shown at the top of the list in terms of photochemical reactivity. How the ingredient reacts in the atmosphere after it leaves the tailpipe determines how much ozone it makes. You can see on this list that methanol has a relatively low reactivity. Methane, which is the primary ingredient of natural gas, is clear down at the bottom. These are the reasons that different alternative fuels are considered to be cleaner fuels than what we have had in the past. And reformulated gasoline follows this same thinking. If you take some of the bad actors out of the gasoline, you achieve the same effects.

On the other hand, nothing is easy. Figure 2.7 illustrates the results of tests of emissions from the natural gas prototype truck. Nitric oxide emissions resulted in 1.96 grams per mile. This was back in 1984 when the standard from this truck was 2.3 grams per mile. That standard today is 1.2 grams per mile, and we had a very tough time getting it to 1.96. So we are very concerned—even though natural gas has many attributes that make it a clean fuel—whether or not we are going to be able to meet the future nitrous oxide emission standards with this fuel.

Figure 2.7: Prototype Emissions and Fuel Economy, 1984

NATURAL GAS RANGER TRUCK (2500 miles)
(4 TEST AVERAGE)

CVS Cold Start, FTP

HC	1.20 gm / mi
CO	0.036 gm / mi
NO_x	1.96 gm / mi
CITY FE	21.2 mpg
HIGHWAY FE	27.3 mpg
M / H	23.6 mpg

Note : Hydrocarbon emissions include Methane; FE is gasoline energy equivalent

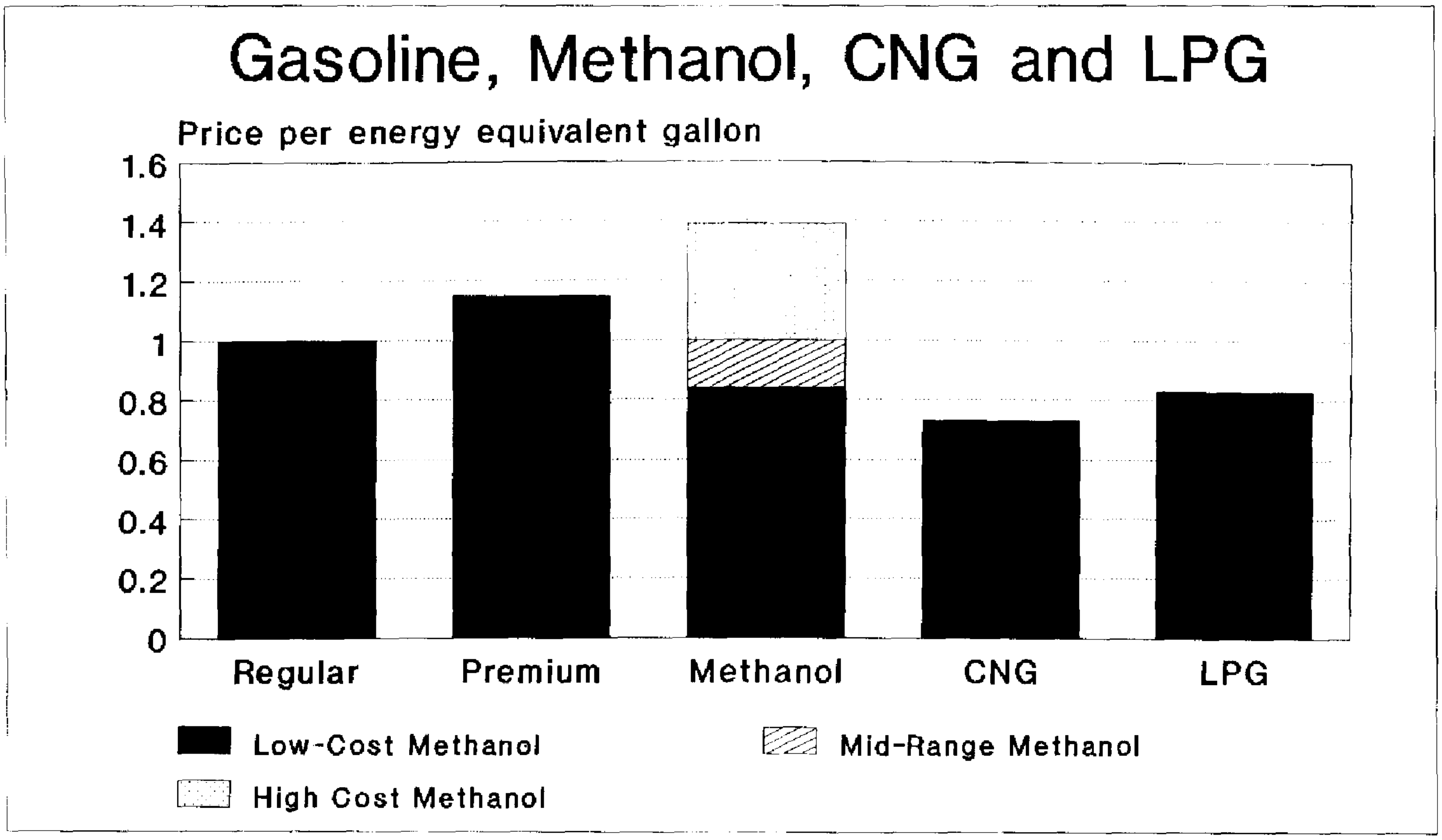
Note: CVS = constant volume sampling; FTP = federal test procedure; FE = fuel economy.
Source: Ford Motor Company.

Driving Range and Cost of Alternative Fuels

Driving range is also an issue. Almost all of the alternative fuels have less energy on a volume basis than does gasoline. The only exception is diesel. That means it is going to take more gallons to go the same distance down the road. Now, in most cases these fuels are more energy efficient, which is very confusing to people. That means you go more miles per energy unit, which is important when we talk about conserving energy, but it is going to take more gallons to do it. That means we have to put bigger tanks on the vehicle. With the flexible fuel vehicle, no matter how big we make this tank the customer will be saying, "Gee, I can go further on gasoline. Why would I want to put methanol in it?" So we have to find incentives for the customer to want to use the new fuel.

Cost, of course, is the driver for most technology. Figure 2.8 projects the cost of the various alternative fuels. In the center are various levels of projection of cost for the methanol, ranging from less than that of regular gasoline to more than that of premium gasoline. These are on a cost-per-mile, not volume basis, so they are comparable to gasoline on a cost-per-mile basis.

Figure 2.8: Fuel Price Scenarios



Note: CNG = compressed natural gas; LPG = liquefied petroleum gas.
Source: Ford Motor Company

Possible Future of Low Emission Fuels

Having brought out all of that uncertainty, I refer you to figure 2.9 for a forecast of where we think we are going with all of this. For liquid fuels, we will see some limited use of reformulated diesel, particularly in intracity applications where the use of diesel fuel in buses and other intracity transportation vehicles is causing a great deal of concern.

Figure 2.9: Forecast of Low Emission Fuel Usage—Liquid Fuels

- REFORMULATED DIESEL:
  - Usage in heavy trucks (especially intra-city), some light trucks, but virtually no cars.
- REFORMULATED GASOLINE:
  - Short term potential for immediate emission benefit; cost and refinery capacity may be issues, as well as catalyst warm-up time.
- METHANOL (M85):
  - Some production applications in short term; long term depends on customer acceptance, fuel cost, and aldehyde control.
- ETHANOL (E85):
  - Minor role due to high cost without subsidies.

Source: Ford Motor Company

In reformulated gasoline, we certainly see a very high potential. Keep in mind now that if the promise of reformulated gasoline does prove to be true—and there is a very intensive auto/oil program going on now getting the data to really make us feel comfortable with these predictions—then reformulated gasoline can go into all of the existing gasoline vehicles already on the road. Whereas, with the alternative fuels, we have to wait for fleet turnover, so it is a much longer process. Thus, we see reformulated gasoline as a very important interim step.

In the long term, we still need the alternative sources of energy. With methanol, we will have some production applications in the short term; the long-term use depends on customer acceptance. But when we look at all of the choices for alternative fuels, we see methanol—from a resource base and from an engineering point of view for the vehicle—as the long-term replacement for petroleum-based fuels.

Ethanol is also an equally good fuel but will play a minor role unless the economics of the production of ethanol can be changed. There is some good work going on at Solar Energy Research Institute, for example, on this.

In figure 2.10 we forecast the gaseous fuels as niche markets, primarily for fleet application. There is a cost advantage that offsets the disadvantage of the much higher-cost vehicle because of the high-pressure tanks, and the lower-cost fuel is really going to help amortize those higher costs. But there will always be a higher-cost vehicle because of the high pressure tank.

Figure 2.10: Forecast of Low Emission Fuel Usage—Gaseous Fuels

- LPG (LIQUEFIED PETROLEUM GAS):
  - Can never fuel more than 2-3% of vehicle population due to limited supply (by-product commodity), even though about 5,000 refueling outlets exist presently.
- CNG (COMPRESSED NATURAL GAS):
  - Niche role in centrally-fueled fleets with high annual mileage. Pipeline capacity may be inadequate to deliver increase in demand in certain regions. Transport of off-shore gas easier in the form of methanol.

Hydrogen use projected beyond year 2025.

Source: Ford Motor Company

Public policymakers have a tough job. It is the biggest systems engineering challenge that anyone could possibly put on the table, not only on the environmental issues but also for national security and our competitive position in a world market. I do not see oil imports as a problem. When people talk about energy independence, my reaction is: independence from whom? The next galaxy? We live in a world market. Our problem is not having enough things to export to offset those imports, and we need to work on that.

Other societal expectations: we all want to have lifestyles of our choosing and not have the government tell us what to do. Federal versus state control is very worrisome. We already build cars for California and the other 49 states. If we start having a proliferation of state legislation, it is going to be chaos in our industry.

Finally, customer satisfaction—no program will be successful unless the customer is satisfied. No matter how much we may talk about it and wish it to come true, unless we satisfy the customer, we will not be able to realize any of this.

Ben C. Rusche
Law Environmental, Inc.

I am pleased to have the opportunity to discuss the high-level nuclear waste program. Nearly 3 years have passed since I left the Office of Civilian Radioactive Waste Management in the Department of Energy as its director and returned to the private sector. In one sense, what a relief. But in another sense, what a disappointment.

I suspect most of you would recognize that relief would be self-evident because many of you and I had an opportunity to discuss and work on things from time to time. And I won't elaborate much more today unless you would really like to hear about it.

The disappointment may be another matter. Disappointment, in my case, because I had hoped that the Nuclear Waste Policy Amendments Act (NWPAA),[1] which was about finalized when I left at the end of 1987, would put the program in a form to proceed on the very cautious and deliberate course laid out by the new act. Disappointment, also, because I am convinced that finding solutions to the high-level waste issue is crucial, if not paramount, in permitting nuclear power to find its proper place in the mix of energy sources for the United States and, indeed, for the world.

My interest in the high-level waste program has remained intense because I am convinced that high-level waste remains the greatest single barrier to the use of nuclear power. Another reason is that I have invested most of my life in working for national security and for making reliable, safe energy available through nuclear processes that are safe and environmentally sound. And, finally, because I have spent the last 7 years working to find a solution to waste management that would serve the interests of our country.

"... high-level waste remains the greatest single barrier to the use of nuclear power."

When I was offered the opportunity to become the first director of the Office of Civilian Radioactive Waste Management by President Reagan,[2] I accepted because of these personal commitments and because I thought the President and the Congress had taken a great step forward with enactment of the Nuclear Waste Policy Act of 1982.[3] There are

[1]The Nuclear Waste Policy Amendments Act of 1987 was included in the Omnibus Budget Reconciliation Act of 1987 (P.L. 100-203).

[2]Mr. Rusche served as Director of the Office of Civilian Radioactive Waste Management, Department of Energy, from 1983 to 1987.

[3]The Nuclear Waste Policy Act of 1982 (P.L. 97-425) directed the Department of Energy to develop one repository for permanent disposal of wastes generated by civilian nuclear power plants. DOE will also dispose of high-level wastes in the repository.

those who thought when I accepted it that I must have come to the end of my faculties because I had already had two tours in Washington and a third tour must surely be convincing evidence that I was incompetent in some way.

I understood, though, that one of my objectives was to determine whether the act could be made to work. Many people doubted it. In fact, I had had an opportunity in my earlier existence in DOE to be a party with some of you in helping put the act together, and I thought that it had a chance at working. Although the act was highly prescriptive from a technical standpoint, in my opinion its most important contribution, or contributions, was its direction to address institutional, social, and political issues. But after 3 years, we and the Congress concluded that changes were needed to allow the process to proceed; thus, the NWPAA. It was, indeed, a major refinement, in my opinion.

As the Administration was then nearing its end, I took the NWPAA enactment as a good sign that I had at least partially accomplished the objective that I had been offered the opportunity to attempt and that it was a good time for me to leave. Unfortunately, the Administration took 2-1/2 years to find a new director. Even more unfortunately, not much progress occurred in those 2-1/2 years, despite the dedicated effort of many of my colleagues who remained in the career service.

I suspect that some of you might even say there might not have been much progress in the 3-1/2 years before I left. But, if so, I'd like to discuss that issue with you perhaps in a smaller group some time.

But here we are today, and John Bartlett has been selected and has been confirmed and is in place.[4] I wish him well. I wished him well in writing, also. I hope that he can be the man for the hour, but it is, indeed, a difficult hour.

I would like to take these few moments to make a number of observations and conclude with some ideas about what we ought to do or how we ought to go about doing what many of us think is pretty self-evident.

I begin with an understatement as an observation: health, safety, and environmental matters have become issues of high concern in the United States and are rapidly approaching that level in the remainder of the

[4] John Bartlett was confirmed as Director, Office of Civil Radioactive Waste Management, Department of Energy, on April 5, 1990.

industrialized world. The need to balance economic progress with health, safety, and environmental issues grows in importance as resources and other limitations are reached. I think most of us would agree with that.

A reliable and predictable energy supply is a key factor in a strong economy, and electric energy is even more strongly correlated with economic strength and growth. I refer you to the National Academy of Engineering 1990 publication, NAE 25, entitled "Energy Production, Consumption, and Consequences," as a good source on this subject, in addition to some of the sources that we saw this morning. But if you haven't seen that, I commend it to your attention.

Consumption or production of energy produces waste products, whether by a biological species, by commercial-industrial processes, or by interstellar processes. In fact, life, growth, energy consumption, and waste are inseparable. On Planet Earth, as the quality of life has grown and the population has increased, so have our appetite for energy and, unavoidably, the accompanying waste that goes along with satisfying that appetite. Nowhere is this more evident than in the United States and in the western, developed nations. It is becoming more evident in the remaining nations of the world.

As the population density has grown and industrialization has proceeded, the amount of waste per unit area has grown. We can no longer send our waste away, because there is already waste wherever "away" might be. You might want to think about that. There aren't any other "aways" left—or not very many, for sure. This is not just a lofty, philosophical statement or a catchy statement. I believe it is a reality.

Indeed, in my years since leaving the Department of Energy, and particularly the years in which I have given most of my attention to hazardous and toxic waste management, the nuclear issues of my past are now appearing again and again in relation to hazardous and toxic waste—issues such as, in the popular vernacular: "I don't like waste." "Let's stop generating the stuff." "If it must be"—that is, waste—"let somebody else pay for it and manage it." And, for sure, "I don't want it in my back yard."

These attitudes, strongest in the United States—with a few exceptions—are becoming evident worldwide. The concerns and issues transcend national boundaries. Indeed, they are global: global warming, of which we are going to hear more about in a short while; transnational environmental effects, subjects that are being discussed in this conference; acid rain; and disposing of one another's wastes.

In view of this background, which I believe is a fair statement of fact, nuclear waste—particularly high-level waste—is still a strong contender for being the most difficult to deal with. But it is closely followed by hazardous and toxic waste and, more broadly, by generally perceived adverse environmental effects of many other types.

Nuclear waste continues to be the lightning rod, but it may become less than the paramount issue it appears to be now as the reality of the unavoidability of waste as a necessary element in the physical world is perceived more broadly.

So what do we do now? We need first to dispel the view that we can do nothing. First, for nuclear waste we have now accumulated about 20,000 metric tons in the United States—not counting the 8,000 tons or so of equivalent physical waste from the weapons program—and we are generating about 2,000 tons a year.

When the waste program under the 1982 Act was established, the waste projections for the life of existing or anticipated plants was about 140,000 metric tons of high-level waste equivalent. Today, I believe, that projection is down to something under 90,000, and maybe approaching even 80,000 metric tons. That is a relatively small amount of physical material.

Just to get a handle on it, I had one of our folks take a look at the most recent set of Form 313s from the Resource Conservation and Recovery Act (RCRA), which lists all of the hazardous wastes that are being generated in the country. For that period—which I believe was for the year 1988, if I am not mistaken—there were 2 billion tons of hazardous waste generated in the United States. That number may shock some of you. It did me, because in looking at the total number of tons or mass of municipal solid waste, I saw that in that same year, we generated only about 150 million tons of municipal solid waste.

The real difference is that under RCRA, if you will recall, many liquid wastes that have pHs outside a certain range contribute a very large fraction. But the amount is still large. For example, in my state, Georgia, the total generation of hazardous waste in solid form is on the order of 75,000 tons per year.

So you might say, "Why all this fuss about nuclear waste?" The simple answer seems to be that in the public eye, things nuclear are frightening and evoke a strong negative response. But one thing is becoming a little more evident to me, and I wish it were a little more evident to some other folks, as well. That is, that nuclear waste has the peculiar—and, in fact, desirable—property that it does not remain the same. It decays with time. In this sense, it is less of a problem than are some of the stable chemical and elemental wastes.

For some of the hazardous wastes that we are discussing—heavy metals, some of the organics, and residues from thermal and chemical decomposition processes—a few percent up to maybe as much as 10 percent of the total amount of hazardous waste is going to be around indefinitely.

I make these comparisons because I believe that it is important for us all—and especially important for you, in your role with the Congress and with the public—to keep these ideas in mind as we engage in the public policy-making process. They are physical facts. But if people would just grasp these facts, some of the concerns and considerations might be dealt with in a more rational manner.

In the cases of both nuclear and hazardous waste, I believe the eventual test of acceptability will depend on quantity of material at a place; that is, concentration as an indicator of its potential health risk. Therefore, we must isolate the waste—whether it is nuclear, hazardous, or toxic—from the biosphere for a time long enough to reduce the concentrations to a tolerable level, either by decay, decomposition, or transformation, or maintain the isolation indefinitely. "Tolerable level" does not mean zero.

The question to be addressed by society, then, is not whether we should do something but rather how, when, and where. And for nuclear waste, the question is the same: how, when, and where do we place the material to allow nature to take its course?

Although some important engineering issues related to confidence in the isolation mechanism for nuclear waste—i.e., geologic stability, ability to characterize and predict transport in various media, climatic conditions, etc.—need to be addressed, the engineering answers, to me at least, appear to be attainable with much greater confidence than we can obtain for many of life's difficult questions.

The most important issues, therefore, are social and political issues that raise fundamental questions. For example, who is in charge? I have had more than one state governor ask that of me. Many of the times when I was asked this by the governor, he had a highway patrolman on either side of me to provide guidance.

How do we agree on acceptable risks or risk levels? That's an issue that I know many of you have worked on. I know John [Ahearne] has worked on it. It is going to be an issue that you who work with the Environmental Protection Agency as well as with DOE will continue to face—not peculiar to nuclear, alone. How do we estimate and communicate risk levels in a comparative sense to an interested and, I think, essential public body? There is a recent National Academy of Sciences publication on improving communications of risk that I would commend for your attention, as well.

Two more obvious questions: Who pays? And how do we communicate ideas that have relevance over thousands of years?

These are not just imponderable questions, I don't think. They are questions that we—and particularly you, in the role that you are in now—will face in trying to work with and for the Congress. It is clear that the answers to these questions will not likely contain absolute proofs. They must, by nature, be estimates or predictions based on the principles of reasonable assurance and extrapolations of historical data and processes. For example, in the geologic realm, past is prologue to the future. Indeed, there is abundant evidence that that is a rational, sound, technical basis for prediction.

We must be careful not to slip into the trap advocated by some that establishes criteria for proceeding that are impossible to meet. If you have worked around this business, you recognize that the most effective stopping mechanism is to establish a test for proceeding that is unmeetable. Let me just mention one example that is very straightforward. "In order to proceed, I need to have absolute proof that there will be no leakage from this container in 1,000 years." Obviously, the thousand-year test is beyond human verification.

Man has always had to deal with the reality that the future cannot be predicted with certainty, although we can now make predictions with much greater confidence than mankind has ever had access to before. The trap of certainty as a basis for proceeding is a trap to inaction.

The answers to these several questions have been developed by the Congress and the President through legislative action, and you have been involved in many aspects. That's the way we in America make such choices, I believe, even though much opposition remains. I think the courts will work their way and hold that such action is constitutional. There appears to be no practical alternative for decision-making that exists in our society short of force.

Some would question whether such profound questions can be made in an open society like ours, because these issues are too volatile, emotional, and difficult. If so, we are headed toward anarchy, in my opinion; and should that course be followed we will have the privilege of enjoying it in a sea of waste—nuclear, hazardous, toxic, and just ordinary garbage.

I am not ready to concede that free men cannot act collectively in their own self interest. Leadership—more than has been evidenced so far—and courage not very commonly found in the political arena will be called for. I am yet optimistic in my youth that there will arise those who will practice such noble traits and provide a high quality of life for our children and theirs in a livable environment. But if they don't—and "they" is "we"—then we will be the culprits.

This discussion is not confined to the United States. Unfortunately, much of the rest of the industrial world—the United Kingdom, France, Sweden, Germany, and Japan—are beginning to see the same results.

Let me hasten to a conclusion with several steps that need attention and are relatively self-evident. We need to resolve quickly the constitutional question of whether the Congress can impose the national will on a state. If it can, then let's get on with the program. The program in the NWPAA, in my opinion, is a reasonable and rational basis on which to proceed. If it can't, the Union is nonfunctional.

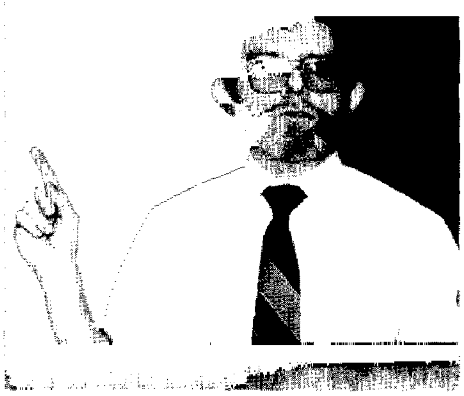
The issue of nuclear waste and other wastes, which we are discussing today, is national in origin—witness all of the several laws that are extant: the Clean Air Act, Clean Water Act, Toxic Substances Control Act, Comprehensive Environmental Response, Compensation and Liability Act (Superfund), NWPAA, and others. If that is the case, then we are faced with national programs and actions or a turn toward a situation in which each state takes care of its own problems, along with its own defense and other national issues.

The actions are the following:

- Be sure that safety and environmental standards are based on the reasonable-assurance concept embodied in many of the regulations. In general, I think many are today.
- Continue to involve and inform the public—and particularly the affected folks—on plans, timing, and expectation. But remember that the test of involvement is not agreement. I hope, again, that that's not a trite statement. But I have had countless occasions in which I have had people in public meetings say, "We want to be involved. We want to participate." We have talked and talked and talked and discussed and argued, and we came to different conclusions. The conclusion by those folks in some cases was that they had not participated because their view did not prevail. If there are several views on a subject, there are going to be some folks whose view is not going to be accepted.
- Establish schedules and proceed. Time costs money. The money being allocated to both the nuclear waste and hazardous waste programs is being spent extremely cost-ineffectively, in my opinion. An 80-percent solution today is worth a whole bunch more than a 90-percent solution 20 years from now.
- Elect men and women of courage and leadership to the Congress to make the hard choices. We need to select folks of courage and leadership to carry out the program.
- Continue our efforts to keep people informed but be very careful that we don't mischaracterize the future expectations. Time and again my experience was to have a prediction or a characterization of the future twisted and turned by someone who had a different objective and find that I was debating that other view about 90 percent of the time.

Finally, since I have brought nuclear waste and hazardous waste into the same context, I thought I would offer a last comparison: the only thing less effective than the nuclear waste program in performance, perhaps, is the hazardous waste program. The only thing that has outspent and will consistently outspend the nuclear waste program is the hazardous waste program—that is, Superfund and the industry.

James J. MacKenzie
World Resources Institute



Today, the United States faces three serious problems related to the use of fossil fuels: climate change from greenhouse warming; air pollution in the form of smog and acid rain; and growing reliance on imported oil, jeopardizing our national and economic security.

These three problems are linked together by the burning of fossil fuels. Unfortunately, these links are too little appreciated. As a result we find ourselves adopting public policies that do not make much sense when all three problems are considered together. In this paper I will briefly examine each of these problems, the connections among them, and the ramifications for national policy-making.

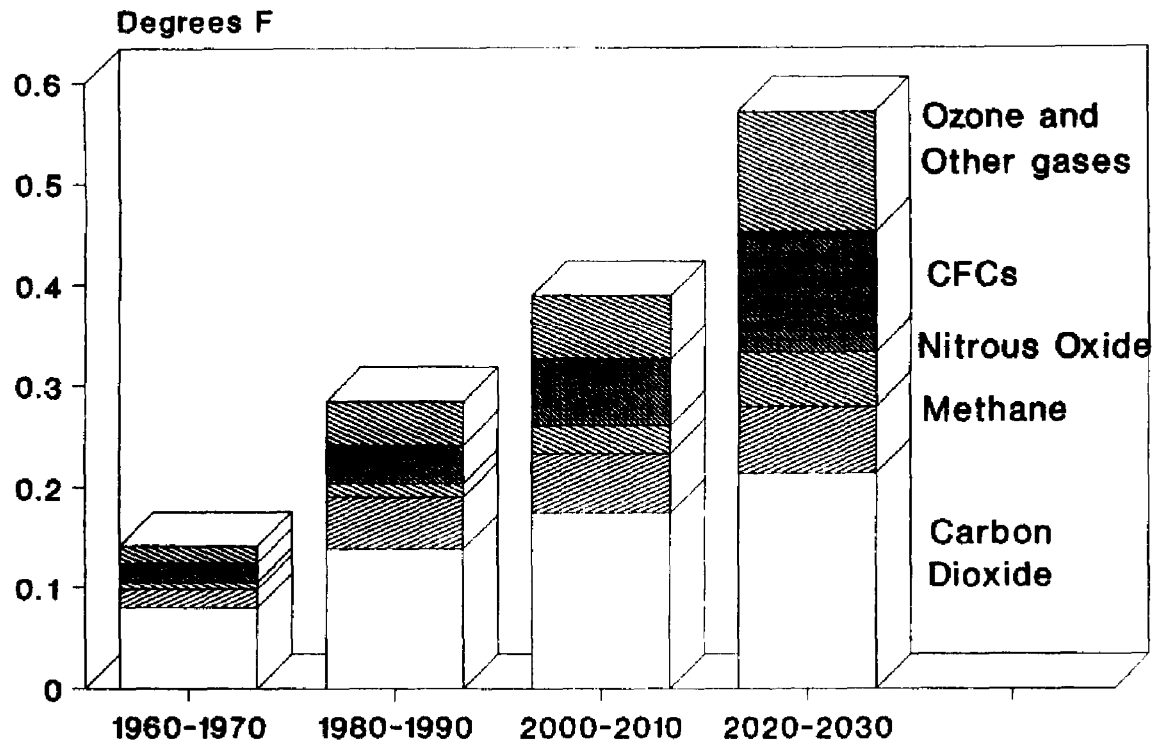
Greenhouse Warming

The release of vast amounts of gases into the atmosphere is leading to an unprecedented global warming. These gases threaten to commit the world, as early as 2030, to a global temperature rise of between 2.7 and 8 degrees Fahrenheit (F). A temperature change near the upper end of this range was sufficient to carry the earth from the coldest depth of the Ice Age into the warmest period ever known.

Greenhouse warming occurs when a blanket of atmospheric gases allows sunlight to penetrate to the earth, but partially traps the earth's radiated infrared heat. Some greenhouse warming is, in fact, a natural and necessary process. Without it our planet would be about 60 degrees F colder, and life as we know it would not be possible. Over the past century, however, human activities have led to the buildup of carbon dioxide and other gases in the lower atmosphere, including ozone, chlorofluorocarbons (or CFCs), methane, and nitrous oxide, that threaten to intensify this warming.

Figure 2.11 shows the expected contribution to global warming from each of the greenhouse gases. Presently, the other gases collectively contribute as much to global warming as does carbon dioxide. At current growth rates, all of the gases are committing the globe, each decade, to a 0.4 to 0.9 degrees F eventual temperature increase.

Figure 2.11: Global Warming From Trace Gases (Temperature Rise per Decade)



Note: Average long-term temperature commitment (per decade) from the expected buildup of greenhouse gases. (For example, between 2000 and 2010, greenhouse gases are predicted to increase the earth's long-term temperature rise by another 0.4 degrees F.)

Source: World Resources Institute adaption of data from Robert T. Watson, NASA, 1986.

The resulting warming is expected to persist for centuries. While no nation can solve the greenhouse problem alone, the United States contributes more to global warming than does any other country and so has a special responsibility to take a leadership role in dealing with it.

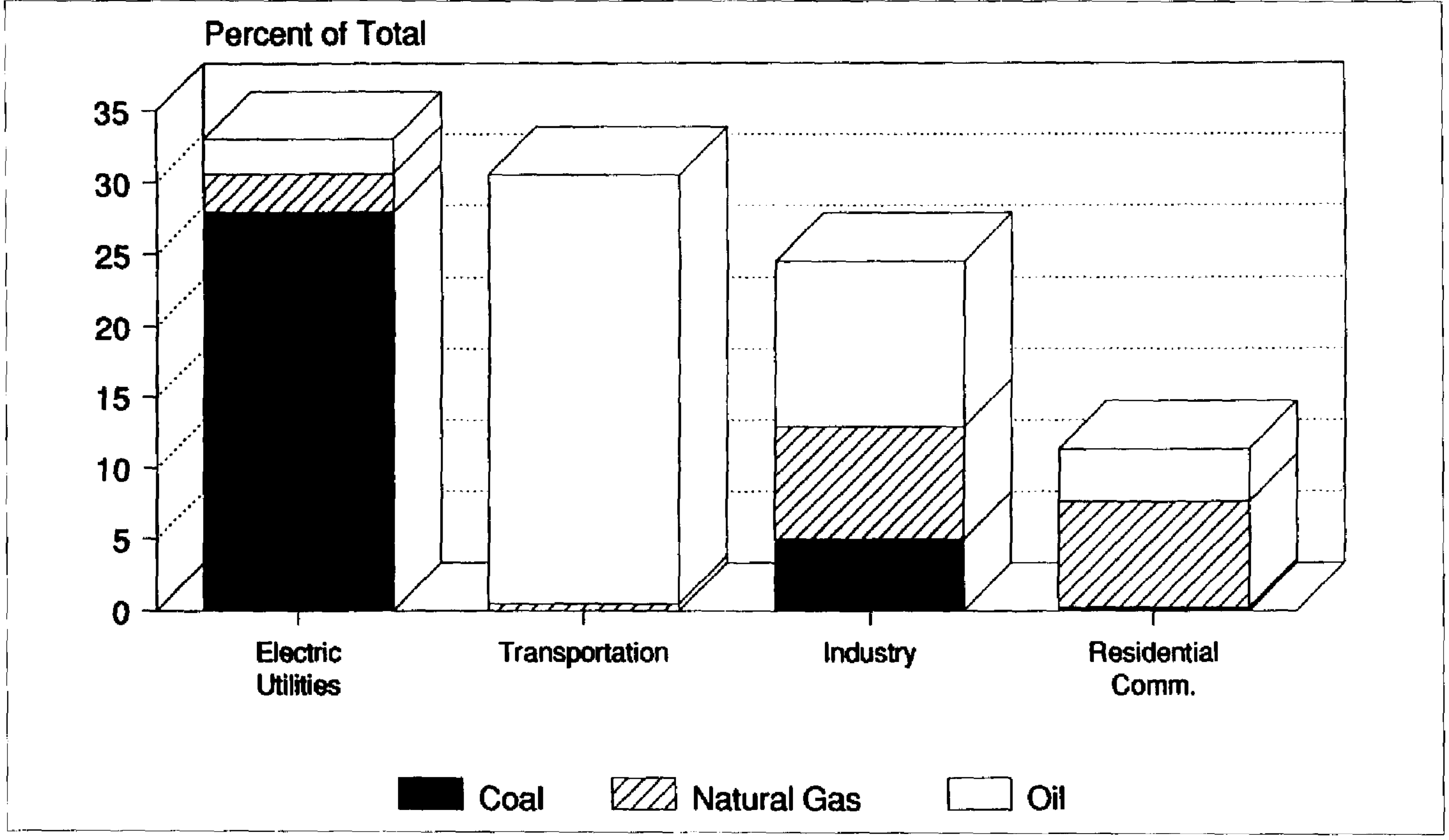
Carbon dioxide is the greatest single contributor to global warming. It is largely the result of fossil fuel burning. Tropical deforestation is another important source of carbon dioxide, though there is considerable uncertainty as to the net amount of carbon dioxide released. It has been estimated that deforestation could account for as much as a third of global carbon dioxide emissions.[5] Carbon dioxide concentrations (including seasonal fluctuations) measured at Mauna Loa, Hawaii, show a steady upward trend since 1958.

The global atmospheric concentration of carbon dioxide has increased about 25 percent since preindustrial times. This increase parallels the burning of fossil fuels and the cutting down of forests worldwide.

In the United States, electric utilities are the single largest source of carbon dioxide releases, accounting for about a third of all emissions. Transportation activities run a close second at 31 percent. (See fig. 2.12.) Over the past 15 years U.S. total carbon dioxide emissions have not changed very much. By offsetting increased coal burning, the use of nuclear power has played an important role in reducing the growth rate in carbon dioxide emissions from electric power plants. In spite of this, as figure 2.12 shows, emissions from power plants and transportation have increased substantially while those from industry and residential and commercial buildings have declined. With increasing electrification and the growing number of vehicles on our roads, emissions from these two sectors are expected to continue growing.

[5] World Resources, 1990-1991. (Washington, D.C.: World Resources Institute, 1990).

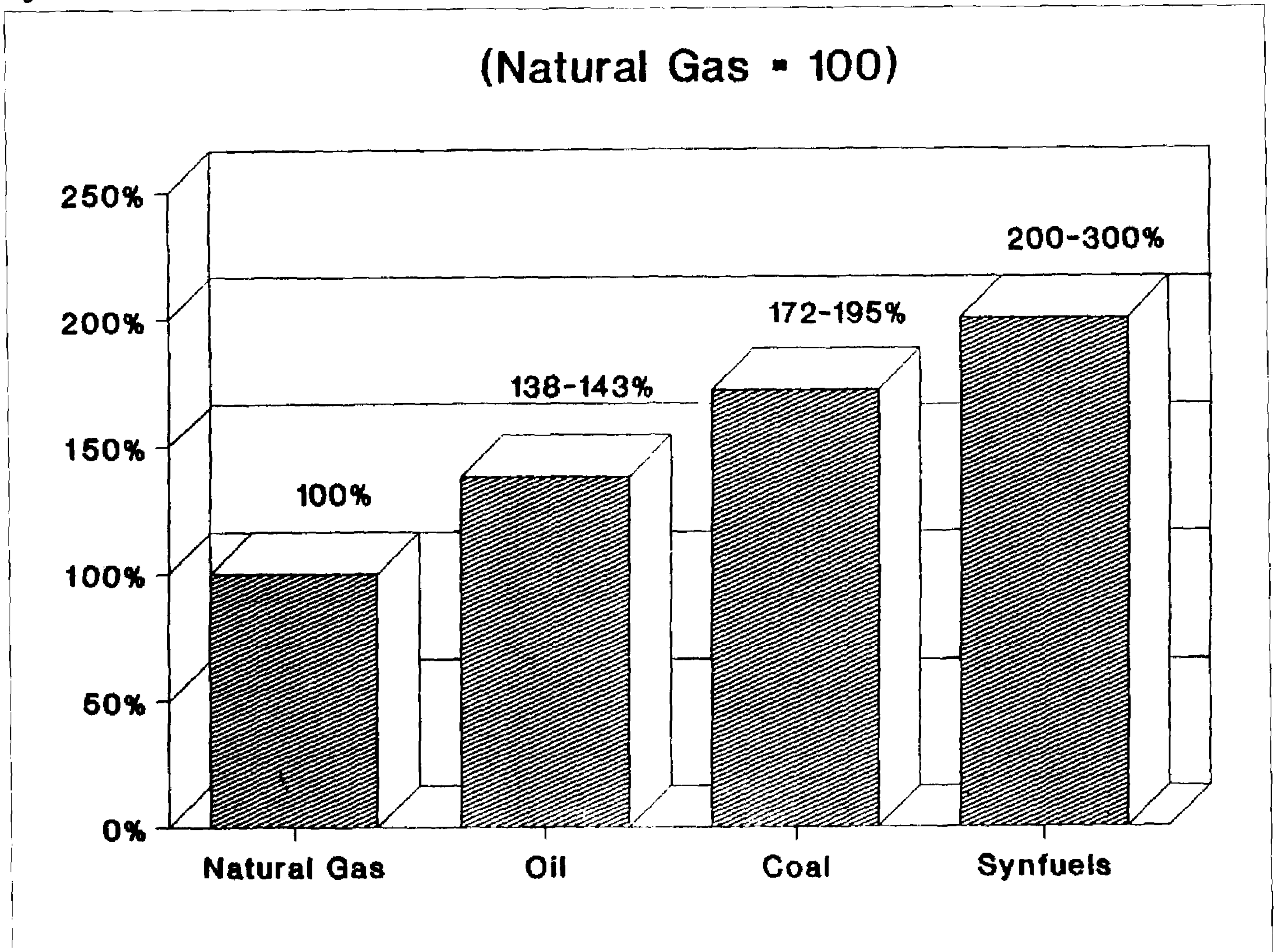
Figure 2.12: 1989 Carbon Dioxide Emissions in the United States by Sector and Fuels



Note: Electric power plants, burning primarily coal, and transportation activities, relying almost exclusively on oil, are the two largest, and growing, sources of carbon dioxide in the United States.
Source: World Resources Institute.

Figure 2.13 shows that not all fossil fuels were created equal. For each unit of useful energy, oil releases about 40 percent more carbon dioxide than natural gas, and coal releases about 75 percent more than does natural gas. Synthetic fuels derived from coal or oil shales would release even more carbon dioxide than coal because the conversion processes require so much energy. Hence, all things being equal, the substitution of natural gas for other fossil fuels would help reduce future greenhouse warming.

Figure 2.13: Relative Carbon Dioxide Emissions



Note: Natural gas emits the least amount of carbon dioxide per energy unit. Emissions from oil are about 40 percent larger than those from natural gas, and coal emissions are about 75 percent larger. Synthetic fuels would emit much larger amounts of carbon dioxide.

Source: World Resources Institute adaption of data from Gordon J. MacDonald, editor, The Long-Term Impacts of Increasing Atmospheric Carbon Dioxide Levels (Cambridge, Mass.: Ballinger, 1982).

In the United States, oil accounts for about half of our fossil fuel supply and about half of our carbon dioxide emissions. Natural gas and coal each account for about a fourth of our fossil fuel supply. Coal, used mostly for electricity generation and industrial purposes, accounts for about a third of carbon dioxide emissions. Natural gas contributes the rest.

Let's look at the sources of some of the other greenhouse gases. The concentrations of CFCs are growing rapidly and are particularly threatening. CFCs and halons are used as foaming agents in various polystyrene products, in fire extinguishers, and as working fluids in refrigerators and air conditioners. CFCs are both very powerful greenhouse gases and depleters of upper-level, stratospheric ozone.

This upper-level, or "good ozone," must be distinguished from ozone in the lower atmosphere, which is a pollutant. Upper-level ozone protects the earth from the sun's harmful ultraviolet radiation. However, when CFCs enter the stratosphere, they break down this upper-level ozone. Increased levels of ultraviolet radiation resulting from upper-level ozone depletion are expected to increase the number of skin cancers and adversely affect the human immune system. In the oceans, increased levels of ultraviolet rays may harm life-supporting plankton. Marine food chains that depend on the tiny plankton may be threatened.

Ozone in the lower atmosphere arises principally from vehicle emissions. This ozone is both a potent greenhouse gas and an important ingredient in urban smog. Global background ozone levels have doubled since preindustrial times, presumably from burning fossil fuels and wood.

Nitrous oxide sources are not well determined but the use of nitrogen-based fertilizers in agriculture is believed to be a major source. The burning of timber, crop residues, and fossil fuels also releases nitrous oxide. Nitrous oxide contributes to both greenhouse warming and to depletion of the ozone layer.

Methane, the principal component of natural gas, arises from rice paddies, termites, cows, landfills, and fossil fuels. Methane levels have been growing by about 1 percent per year and have doubled over preindustrial concentrations. Methane emissions have closely followed population growth, and represent an important, direct link between population and global warming.

Vehicles contribute indirectly to the buildup of atmospheric methane. The carbon monoxide from vehicle exhausts slows down the normal processes that remove methane from the atmosphere.

With all these gases at work, what will be the likely effects of global warming? The oceans, which act as huge heat sinks, have delayed by perhaps a few decades the warming already committed to from past emissions, estimated at 2 to 5 degrees F. While uncertainties persist, there is general agreement that global warming will occur. By the year 2050, Washington, D.C., which now averages 35 days a year over 90 degrees F, could have 85 such days. Chicago could go from 16 such days to 56.

A reduction in precipitation and soil moisture is expected in the midwestern United States. Precipitation patterns will change, though exactly how is still uncertain. Some areas will receive less rain, affecting rivers and water supply. Ecosystems, both plants and animals, will be forced to migrate northward to keep up with changing climate conditions. Those unable to do so because of the rapid rate of climate change or because of inhibiting structures, roads, or developments may decline or disappear altogether.

Sea levels are predicted to rise about a foot by the middle of the next century and by up to 3 feet by the end of the century. Sea level rise is the result of thermal expansion of the oceans and the melting of land-based glacial ice. A 3-foot rise could have devastating effects on coastal areas around the world. Many parts of the Gulf Coast and Florida will be more often inundated from a combination of higher ocean levels and more intense tropical storms. Protecting U.S. coastal cities against a 3-foot sea rise could cost hundreds of billions of dollars. Many rich coastal ecosystems, fisheries, and arable land around the globe will also be lost.

The summer of 1988 witnessed record temperatures across the country, a drought in the Midwest, record levels of smog in cities, devastating fires in the West, and the worst tropical storm ever documented in the Western Hemisphere. Though not proving that the greenhouse effect has arrived, these events are indicative of what climatologists are expecting to result from global warming.

Air Pollution

In the summer of 1988, 76 U.S. cities exceeded the Environmental Protection Agency's (EPA) health standard for ozone by at least 25 percent. In 1988, about 150 million Americans were living in areas that exceeded the ozone standard. Thirty-nine million live where the carbon monoxide limit is routinely violated. Los Angeles exceeds these EPA limits for 2 out of every 3 days of the year, more than any other American city.

These air contaminants seriously affect asthmatics and others who suffer from respiratory ailments. Healthy lungs are damaged. Pollutants, particularly ozone, irritate the eyes and are believed to weaken the human immune system.

The principal precursors to this urban pollution are carbon monoxide, nitrogen oxides, and organic compounds. The sun's heat causes these chemicals to react with each other to create ground-level ozone, the principal component in urban smog.

The principal source of these precursors is transportation, accounting for close to 70 percent of all carbon monoxide emissions, and 41 percent of the nitrogen oxides. The warmer it gets, the more these reactions are derived, the more ozone is created. In cities where the air stagnates, high smog levels can persist for days. Ozone also inflicts damage outside the urban arena, impairing the productivity of crops across the country. Beans, cotton, winter wheat, and peanuts are particularly vulnerable. U.S. losses in crop productivity attributable to ozone are estimated at up to $5 billion per year.

Acid deposition and ozone, resulting from vehicle and power plant emissions, are also implicated in vegetative damage, especially at mountainous sites in the eastern United States. The average acidity of cloud moisture along the Appalachian Mountain chain is 10 times greater than cloud acidity at nearby lower elevations. The peak cloud acidity at several of these mountains reaches 2,000 times the acidity of unpolluted rainwater. In forests, ozone and acid deposition accelerate the leaching of nutrients from plant foliage. Acid deposition also leaches essential nutrients from forest soils, threatening long-term ecological changes.

The cumulative effect of the acidity and ozone is to leave trees and crops more susceptible to natural stresses, such as pests, disease, severe cold, and drought. The Black Forest in Germany, Mt. Mitchell in North Carolina, and the Appalachian Mountains from Georgia to New Hampshire are all experiencing high levels of air pollution; and all are suffering extensive forest dieback. Buildings and other structures are also susceptible to the ravages of acid deposition.

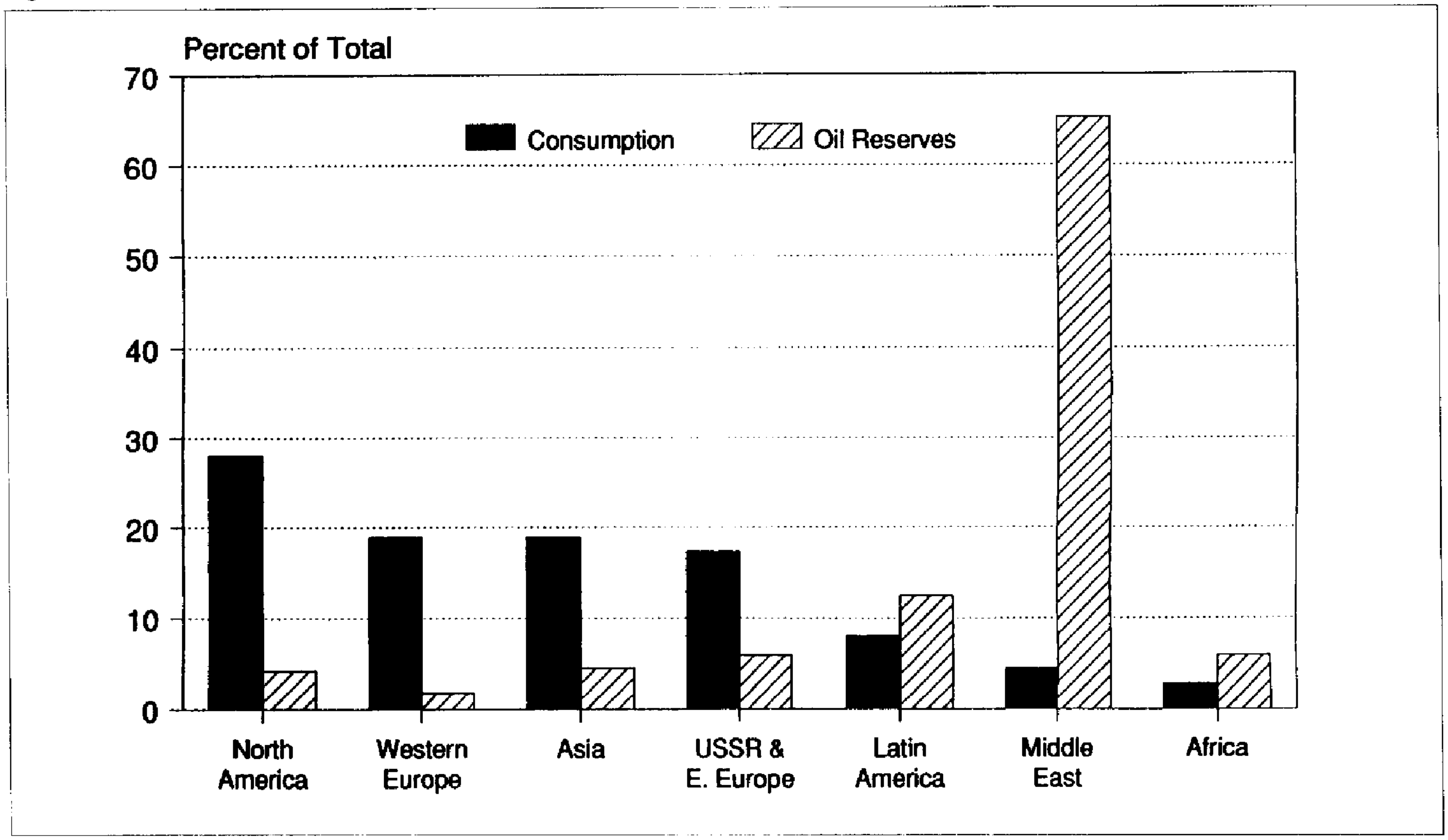
The sources of air pollution are largely the same as the sources of greenhouse gases. Fossil fuel power plants are the largest source of sulfur dioxide, accounting for two-thirds of emissions. Power plants also account for 29 percent of the nitrogen oxide emissions, another major precursor to acid precipitation. Transportation, however, is the largest source of nitrogen oxides, accounting for 41 percent of all emissions.

In response to the Clean Air Act, many utilities built tall stacks to eject the pollutants further up into the air. However, this approach to meeting local Ambient Air Quality Standards led to serious longer-range acid rain problems, as the pollutants eventually oxidize to sulfuric and nitric acid: acid rain.

Oil Insecurity

U.S. oil consumption accounts for about half of our carbon dioxide emissions and much of our air pollution. Our heavy reliance on oil, primarily for transportation, also threatens our national and economic security. Our problem is straightforward. North America consumes 30 percent of the world's total oil but has only 5 percent of world proven reserves. (See fig. 2.14.) And despite a massive drilling effort in the 1970s and early 1980s, U.S. oil production in the lower 48 states continues to decline. As a result, the United States has become increasingly dependent on imported oil. The U.S. now imports over 42 percent of its supply, at an annual cost of over $50 billion. By 1995, according to the Department of Energy, imports could reach 50 percent.

Figure 2.14: 1989 Global Oil Consumption and Reserves



Note: North America accounts for almost 30 percent of global energy demand with less than 5 percent of world reserves. Most of the remaining oil lies in nations in the Persian Gulf.

Source: World Resources Institute and BP Statistical Review of World Energy, June 1990.

Much of the oil will come from oil-rich, but politically insecure, Persian Gulf nations. In 1989 the United States obtained over 12 percent of its oil from Middle East suppliers; in 1973 we obtained only 5 percent. Unless the United States takes major steps to reduce its use of oil, especially in transportation, it will become increasingly vulnerable both economically and politically.

Observing the Connections

Clearly, climate change, air pollution, and oil insecurity must be dealt with as linked problems. And we must develop long-term strategies that fully take the interrelatedness into account. In the past, policies have too often ignored these linkages.

". . . climate change, air pollution, and oil insecurity must be dealt with as linked problems."

Recent decisions to reduce efficiency requirements on new vehicles and to permit higher speed limits on our highways are just two examples of narrowly focused and counterproductive policies. Both of these policies have led to an increase in oil imports and greater greenhouse warming due to greater fuel use and increased transportation emissions. Higher driving speeds also lead to increased levels of air pollution.

Strategies that will effectively combat climate change, air pollution, and oil security should focus instead on the following: increasing national energy efficiency, reducing air pollution, and beginning the transition to nonfossil fuel technologies.

In terms of efficiency, shifting to highly fuel efficient vehicles will curtail carbon dioxide emissions, mitigating the greenhouse impact. Our dependence on oil imports will also decrease. Vehicles attaining over 50 miles per gallon are now in dealer showrooms and concept vehicles capable of 70 to 100 miles per gallon have been developed. State and federal governments can encourage the use of these highly efficient vehicles through their own purchasing policies and by adopting variable sales taxes or variable annual registration fees that increase for fuel-inefficient vehicles. The Congress should also enact a carbon fee on fossil fuels to begin to internalize the social costs from increased global warming.

Reducing the number of vehicles on our roads and highways is another effective strategy to encourage more efficient fuel use. Long-term investments in public transportation will also be required and will lead to reduced global warming, less air pollution, and fewer oil imports.

There are still vast untapped opportunities for efficiency improvements in homes, commercial buildings, and factories. Indeed, the Congress recently took an important step in this area. In 1987, the Congress passed legislation establishing national efficiency standards for major new appliances starting in the early 1990s. As highly efficient refrigerators, air conditioners, and lights are gradually introduced, the results will be fewer emissions from power plants and less risk of climate warming and air pollution. Our greatest challenge is to find creative incentives to encourage more widespread use of these efficient appliances.

In the efforts to reduce air pollution, vehicles are once again a major focus. Under the revised Clean Air Act, tighter emissions standards will be imposed on new vehicles. As a result, carbon monoxide, nitrogen oxide, and organic compound emissions will all decrease, as will levels of ozone and acid deposition. At the same time it is essential to toughen inspection and maintenance programs for existing vehicles. Recent evidence suggests that a few older vehicles are, in fact, responsible for a large percentage of urban pollution.

The limited use of cleaner fossil fuels in buses, trucks, and commercial fleets is another near-term option for the transportation sector. Compressed natural gas vehicles emit less carbon dioxide and other pollutants and could help reduce both urban air pollution and the greenhouse impact. Methanol, on the other hand, would have about the same carbon dioxide emissions as gasoline (if made from natural gas) and would be imported as well. Its potential clean air benefits are also quite speculative at this time. The use of more efficient production technologies—such as the new highly efficient gas turbines—to generate electricity using natural gas can also improve air quality.

Soon we must begin the long-term shift away from fossil fuels. Wind turbines now account for over 1 percent of California's electricity supply. The new Luz steam-generating solar power plants are also producing electricity at competitive costs. The use of photovoltaic cells should also be actively and aggressively supported to provide electrical power in the years ahead. New, passively safe nuclear designs may also prove feasible. There is a briefing on July 17, 1990, sponsored by the Environmental and Energy Study Institute, to review progress in this latter area.

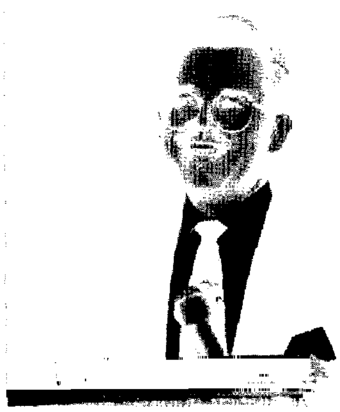
In the transportation sector, hydrogen-powered vehicles are an emerging possibility to replace the fleet of oil-utilizing cars. Electrically powered vehicles are another potential option. The development by DOE and Isuzu of "ultra capacitors" may significantly advance the introduction of electric vehicles.

A Willingness to Change

The essential elements of a strategy to reduce the threats of greenhouse warming, air pollution, and energy insecurity are clear. Dealing with these risks will require a willingness to adjust the way we live and to tax ourselves now to benefit our children later. It is already too late to avoid some degree of climate change or to undo the damage air pollution has caused. But it is not too late to contain those damages or to send the heirs to this planet the message that ours was a generation that cared about how we lived in the world and how we left it for others.

Panel 3: Managing the Department of Energy

Joseph S. Hezir
Office of Management and Budget



Oftentimes I feel that the Office of Management and Budget (OMB) and GAO do not communicate as much as they should. I think that sometimes because we work for different branches of government we tend to view ourselves somewhat as competitors or rivals. But I do believe that we have a lot of common interests, and that there is a lot to be gained by sharing information and ideas on various issues on which we both work. And so it is in that light that I am very pleased to be here with you this afternoon.

There are four areas that I would like to cover. First, I thought it might be useful to give you a 2-minute sales pitch on what OMB does. Secondly, I'll talk briefly about some of the major budget trends in the Department of Energy over the past decade. Thirdly, I'll talk a little bit about some of the major issues in the Department right now. And fourth, I'll talk mostly about what I see as some common characteristics of a number of the issues that are presently facing the Department.

OMB is a relatively small organization. It is in the Executive Office of the President and employs about 500 people. We have the following six major functions:

- We participate in all of the Executive Branch policy development processes, including the Domestic Policy Council and the Economic Policy Council.
- We initiate a number of policy actions through the budget process.
- We coordinate and clear all communications with the Congress on proposed legislation.
- We issue statements of policy on all bills that are going to the House and Senate floor.
- In the regulatory area, we have certain responsibilities by statute and executive order to review significant agency regulatory actions prior to their publication.
- On the management side, we have a number of responsibilities over federal procurement policy. We also have major initiatives underway in management by objectives and in financial integrity.

In the budget area—the area that I deal with most on a day-to-day basis—we not only set the macro budgetary targets, but we review and approve all of the agency budget proposals for inclusion in the President's budget. We then work with the Congress in the budget and the appropriations processes to try to obtain enactment of those proposals.

In the execution area, we oversee the agency execution of funds through the apportionment process, and also, if the need arises, issue sequestration orders under the Gramm-Rudman-Hollings Act.

OMB's policy and budget functions are organized under four Associate Directors. Under each Associate Director there are two program divisions and one smaller, special studies division. I am responsible for the Energy and Science Division, which is one of the program divisions. I oversee not only the Department of Energy, but also NASA [National Aeronautics and Space Administration], the National Science Foundation, and a number of smaller agencies in the energy and science area.

Turning now to the Department of Energy budget, I don't want to go into the details, but I thought it might be useful just to step back for a minute and look at what has happened to the Department of Energy over the past decade. OMB tends to organize DOE policy and budget issues in three areas. The first is the Department's Atomic Energy Defense responsibilities. The second is the general science programs—primarily the high-energy and nuclear physics programs. The third category includes all of the other energy programs. We tend to think about them in these three categories because, particularly over the past decade, the kinds of policies that have been applied have been very different in these three areas. The following examples illustrate that.

In the 1980s, funding for the Atomic Energy Defense programs almost tripled. That funding trend has followed the same path as the Department of Defense buildup that occurred in the same period, although in the latter part of the 1980s, some growth in DOE's defense activities has been due to the growth of the environmental cleanup programs.

The science area has also been an area of real growth over the past decade. Mainly in the high-energy physics area, a number of new projects have come on-line, such as major upgrades at Fermilab. We are building a new project in the nuclear physics area at Newport News. And in the last few years we have begun to increase funding for the Superconducting Super Collider.

Overall, funding for energy programs has been relatively stable, although there has been a wide variety of "puts and takes" going on. One point worth mentioning is that a number of the DOE programs collect revenue—the naval petroleum reserves, the power marketing administrations, and the uranium enrichment program. Therefore, from a budgetary standpoint, the net budget outlay for energy programs is quite small. But that is masked, in part, by the large revenues coming in primarily from those three programs.

Turning now to the list of issues, when I prepared for this talk I started to think about what particular management or program issues I might want to discuss. So I sat down and sketched out what I thought were some of the major issues currently before DOE.

I see the two biggest issues in the defense areas as the near-term issues associated with restarting the facilities at Savannah River and Rocky Flats, and the longer-term issue of the modernization of the defense complex. In the science area, the biggest issue is management of the Superconducting Super Collider project. There are a wide range of energy issues, beginning with the National Energy Strategy and including energy research and development issues, the nuclear waste program, and the future of the uranium enrichment program. Efforts are underway in the Congress to expand the size of the Strategic Petroleum Reserve. Repayment practices of the power marketing administrations are being examined and a new issue is the future of the fusion energy program. In addition, there have been several cross-cutting issues within the Department—including environmental cleanup activities and the Department's role in the technology transfer program.

After I made this list, I tried to decide which ones I really want to talk about. The ones that I am most interested in? The ones I felt that you all might be most interested in? Or some combination? The more I thought about it, the more I tried to decide if there are some generic, underlying issues that clearly cut across all of these program areas. As analysts, in looking at these programs and conducting reviews and studies, are there some basic points that we ought to consider? I came up with five that I have labeled as common characteristics of most, but not all, DOE programs.

First, almost all DOE programs are very expensive and multi-year in nature. The difficulty is that DOE operates in an environment in which they must compete for limited budgetary resources, both within the Executive Branch and in the Congress. Moreover, they must compete in an annual cycle. So it becomes very difficult to plan and to execute expensive, multi-year projects in that kind of environment.

Secondly, most of these programs have many scientific and technical uncertainties. You could probably have a conference about the scientific and technical issues on any one, single program, and you will find differing scientific views about whether or not the Department is doing the right thing or not. Because many DOE programs are very much one-of-a-kind projects, it is very difficult to draw analogies in reviewing these.

Thirdly, many DOE programs are very complex, and very much on the cutting edge of U.S. science and technology. In addition, many of these programs have very extensive, complex, and often contentious interactions with outside groups. In both the environmental cleanup area and the defense modernization area, for example, the Department is involved with state and local governments and environmental groups. Consensus must be reached on many difficult issues. This is also true in the siting of the nuclear waste depository. Even in the case of the Super Collider, because Texas is going to be contributing up to $1 billion of the cost, a whole set of factors will complicate DOE's dealings with the state. These factors will further complicate DOE's ability to make future decisions on that project.

Fourth, these programs involve interactions with other federal agencies, particularly with the Department of Defense on the atomic energy defense programs. In the last 6 months DOE has had increasing interactions with NASA in terms of the potential role of certain nuclear power programs in the future of space exploration.

Fifth, almost all the major DOE programs rely on contractors for program execution. That, in itself, creates a whole set of management and policy issues. These issues will come up in any and all of these program areas.

". . . it is difficult to sort out the roles and responsibilities of the contractors versus those of the Department [of Energy]."

Finally, when you look within the Department, you often find that the various management roles and responsibilities are unclear, to put it mildly. I think it is difficult to sort out the roles and responsibilities of the contractors versus those of the Department. And even within the Department there are questions about the roles of the field offices versus the role of headquarters. And, finally, there is the question of the internal oversight mechanisms within the Department. I think John Layton [Inspector General, Department of Energy] will talk about the Inspector General's office. But, I also wanted to point out to you that DOE's policy office and Comptroller's office play very important roles—or at least should play very important roles—in ensuring coordination and consistency across the Department.

To illustrate this last point, over the past year now, since Admiral Watkins has become Secretary [of Energy], he has made a number of criticisms about DOE management. Over the past year, he has begun to issue directives to correct what he sees as some of the management problems. These directives are called "Secretary of Energy Notices," or SENS. I think over the course of the past year there have been somewhere between 15 and 20 SENS.

One of the areas in which he has tried to clarify the Department's management responsibilities is in the defense programs with respect to environment, safety, and health responsibilities. Secretary Watkins put out last year something called SEN-6, which was subsequently amended by SEN-6A. A group of DOE staff briefed us on SEN-6. It was a very confusing directive. While they were explaining it to us, one of my colleagues sat down at the blackboard and tried to draw a little flow chart and, after the meeting, went back to his computer and created one. Now, I'm not going to try to explain it to you because, first of all, I don't have enough time. Secondly, I don't think that I could. But this was supposed to be a management solution, not a problem.

And this is something that is now being implemented on the Admiral's watch to correct what he perceived as a previous problem. After we sketched out the flow chart, I sent a copy to the undersecretary and I asked him to explain if this was an accurate representation of SEN-6. But, unfortunately, he has not responded. So I can't tell you if it is or not.

Let me just end by repeating that the characteristics that I have pointed out are common to a number of issues and programs within DOE. I would hope that, as analysts who will have to go in and do audits or evaluations of these programs, you keep some of these more generic points in mind, because—regardless of the program—you will find that they keep coming up.

John C. Layton
U.S. Department of Energy

The most important thing I think I can do for you today is answer questions. In the meantime, I think it is important to know that things are changing at the Department of Energy. The philosophy of management is changing. When I got there in January of 1986, it was certain that the operations offices were the places where the power was. They believed they managed DOE activities. And the philosophy was, "Stay out of their business and let them run the show."

And then, in about 1989, we had the raid on DOE's Rocky Flats Plant. I think if you can look at one event in the history of the Department of Energy that has caused change, it was the Federal Bureau of Investigation (FBI) raid at the Department's facility at Rocky Flats with the Environmental Protection Agency (EPA), FBI, and, by the way, the Department of Energy's Office of the Inspector General arriving with some 100 people to question business practices. Why is it that we have allegations of environmental wrongdoing here? How did it get that way?

The Secretary [of Energy], in response to that raid, started the Tiger Team exercises, and they uncovered numerous problems at numerous locations that needed correction. I think that all of that focused attention on the management structure of the Department of Energy and on who is running the operation. Who is accountable and who is responsible? Who is responsible for what is going on? Who accepts responsibility? The theory in the past had been that we hire a contractor and make it [the contractor] responsible. I don't think that sells in the courts, and I don't think it sells with the Congress of the United States, and I don't think it sells with the current Secretary of Energy. I don't think he believes you can give away responsibility, and I don't, as the Inspector General.

That's what was really happening, and that's the change we are seeing happen. It is a great struggle because it costs money to exercise authority. And that's where the Office of Management and Budget, the Congress, and the Secretary have to get their planets aligned some time in the near future. It does not come cheaply.

I call it a problem of deferred maintenance. We produced weapons on time at the right quantity for 40 years, but apparently at a price that was too low. We did not dispose of our waste. I use the rather crude analogy that an organization or an organism that is constipated can't live long. You've got to get rid of your waste. We apparently have not done it in an environmentally sound fashion.

That constipation has now pressured the whole system. We can't run a factory, we can't dispose of the waste. That's really where we are today—trying to get rid of the waste. There is maintenance that should have been performed on these facilities. And when I go through the list of areas that I think require a lot of emphasis, restoring and protecting the environment is probably one of the most important things we are going to do if we plan to run a Department of Energy that produces nuclear weapons. Even if you run one that doesn't produce nuclear weapons, you have hazardous chemicals in other operations we do—polychlorinated biphenols (PCBs) in the Power Marketing Administrations, for example. We have to be able to protect the environment.

I gather some of you are from the field. If you have looked at the Y-12 facility not as a member of the family there,[1] but as an outsider, it looks like Pittsburgh did 30 years ago. It is a mill town. If you look at the production line there—I'm from Pennsylvania, so I accept responsibility for Pittsburgh—they are in no way modern. Material goes from this end of the plant to that end of the plant, back to the middle, over to here, over there, maybe something is done in that building over there, and then out the end. You talk about accountants and internal controls, production line economies of scale, efficiencies of production—it ain't there.

An interesting anecdote: I was down there several years ago and I heard a discussion about a new cafeteria. My thought was, "Why a new cafeteria? Why have this place at all? Is there another place to do this job? Could it be done someplace else? Could it be modernized? Should a cafeteria be part of some other structure that could be erected?" Those are questions that the modernization studies are intended to resolve, and they came about after that visit.

The controlling, processing, and storing of nuclear waste: not only do we have the past-tense problem—as was evidenced, for example, in the Fernald [Ohio] settlement, which I think is costing us $68 million to resolve—we still have a current problem of waste being generated and stored properly and safely. And when I use the word "properly," I mean legally—keeping individuals out of jail is as real as I can make it. If you

[1]The Y-12 Plant is one of three major facilities located on the Oak Ridge Reservation in Oak Ridge, Tennessee. The Y-12 Plant was constructed in 1943 as part of the Manhattan Project. Its initial mission was the separation of fissionable isotopes of uranium by the electromagnetic process. Today, the Y-12 Plant has four principal missions: (1) defense responsibilities related to the production of nuclear weapons components and support to the DOE weapons design laboratories, (2) processing of source and special nuclear materials, (3) providing support to other Energy Systems installations, and (4) providing support to other government agencies.

violate the Resource Conservation and Recovery Act (RCRA) and some of these other environmental laws, you are subjecting yourself to a criminal conviction.

Outside of the defense complex, the establishing of a policy to ensure the national short- and long-term energy needs is extremely important. We have a country that has become increasingly dependent on fossil fuel, not less dependent. I, as a consumer, think of the day somebody shuts off the tap. I watch ships run aground and I watch folks get upset over pollution of the beaches. The shrimp were in jeopardy down there in the Gulf of Mexico—if you believe the newspaper—for a while when that huge supertanker was taking on water. And I wonder what we do when the same groundswell occurs against shipping oil that has occurred against use of nuclear energy. Do we shut that off also?

Where are we as a nation if we shut off the supply of foreign oil? We consume more energy than we generate in this country. These are issues that I don't have answers to, but these are ones confronting us as taxpayers and as citizens of this country.

Another area requiring emphasis, in my opinion, is effective and efficient energy research and the promoting of technology advancement.

Joe's [Hezir] chart mentioned technology transfer. I think it is that whole gamut of things. Technology transfer is only a piece of it, and maybe a piece in which the internal controls are in most need of short-term attention. We have a lot of legislation in that area, and I am not convinced at this point that the internal controls are yet adequate in that area.

The "work for others" area is really just a subset of how the Department of Energy runs its own business, but it gets a lot of attention. It focuses a lot of other entities' attention on the Department of Energy's own administrative practices. I think that is an area that needs additional attention.

"We have roughly 16,000 government employees in the Department of Energy and roughly 160,000 contractors . . . . But is that the right mix of people?"

Joe [Hezir] also had the use of contractors on his chart. We have roughly 16,000 government employees in the Department of Energy and roughly 160,000 contractors. The number runs from 135,000 to 140,000 to 160,000. Pick the day and the number depending on how far down the sub-tier line you go—subcontractor tiers. But is that the right mix of people? When you talk about responsibility and you look at a particular operations office and a particular function, is the mix of people right for accepting responsibility and administering the authority that they have? Where is the Inspector General in these areas?

We have, over the next 3 to 5 years, decided to spend some 55 percent of our audit effort in the environment, health, and safety area; the weapons programs; the waste disposal; and the safeguard and security areas. That's a rough estimate, and it is over a 3- to 5-year period. We expect about 25 percent of our effort in audits to deal in procurement and grants management; the technology transfer issues; and deterrents to fraud, waste, and abuse. About 20 percent will be on the Strategic Petroleum Reserve, Power Marketing Administrations, Superconducting Super Collider, and other financial management areas.

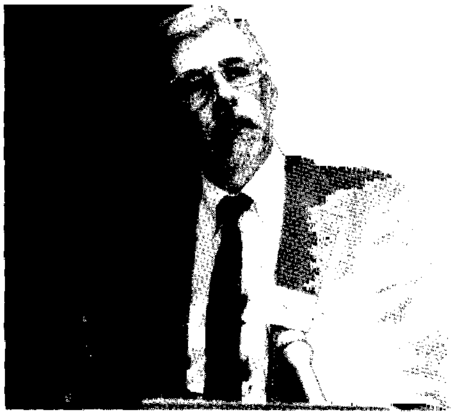
While we are doing that in audits, because of my concern over responsibility, accountability, and how the department is running, we have started general management reviews of the operations offices and the Power Marketing Administrations. We also intend to do management reviews at the headquarters level eventually. We got our feet wet with our first job when we did the San Francisco operations office. I hope by Friday [July 13, 1990] that the official draft of that report may be on my desk, but that's as good as a GAO estimate of the day a report will be ready.

We have about 73 recommendations in there at this point, and I think that it has met with a fair amount of acceptance by the people who were reviewed. I'm so optimistic about it that we are about ready to announce the office where we're going to do the next review.

We have several audits underway in the environmental area and in the waste disposal area. We have ongoing audits in the testing, training, budgeting, and waste minimization areas. And we recently issued a job on the final audit of the major systems acquisition area. DOE has a track record of failed big projects coming in late, over cost, over budget, or never being started—just canned. We think if the policies and procedures that were in place—the major systems acquisition policies—had been followed, there may have been fewer of those historical disasters.

Leonard Weiss

Committee on Governmental Affairs Staff, U.S. Senate



Judy England-Joseph of GAO [Associate Director, Energy Issues, Resources, Community, and Economic Development Division, who introduced the panel] actually laid out all the management issues in very succinct fashion, so my contribution will be more in the nature of elaboration. She mentioned contractors first, and that is perhaps the major management issue at DOE because they cut across every area of activity in the Department.

Please bear with me as I would now like to quote extensively from the findings of an investigation of DOE reliance on contractors.

The primary findings are as follows: the department's reliance on contractors is so extreme that if the terms of its contracts, the resumes of its contractors, and their employees, and the contractor work the department adopts as its own are to be believed, it is hard to understand what, if anything, is left for officials to do.

Reliance on contractors is not limited to a portion of the department's activities or to discrete components of DOE. It permeates virtually all of the department's basic activities—regulation, spending, and internal management—at virtually all levels of the organization chart.

In law and in theory, the use of contractors to assist in the central planning and management tasks of government is to be limited to a temporary or intermittent basis, typically where contractors provide unique expertise that is otherwise lacking in government. In fact, contractors have come to serve as a permanent work force for Federal energy programs. They remain on the job as officials and even administrations come and go as the official energy bureaucracy is organized and reorganized.

The contractors who now possess unique expertise have often obtained it through years of learning on the government payroll.

The department does not keep minimally adequate contract records. Top management doesn't have the basic information and analysis needed to understand how DOE relies on contractors for planning and management, much less to evaluate the effectiveness of such reliance, and to control waste and duplication. For example, this investigation revealed that the department's official contract files did not contain complete copies of contracts under which DOE is paying out millions of dollars.

I don't think [DOE's Inspector General] John Layton would find this a surprise.

DOE was unable to produce hundreds of items of work claimed to have been delivered by contractors under even very recent multi-million dollar contracts. Responsible DOE officials could not readily report the extent to which contractors were being used for such work as the drafting of official DOE testimony, the development of legislation, the preparation of budget materials, the writing of official plans, and the answering of correspondence, and often were unaware that DOE uses contractors to do this work.

I could go on and on. Let me just add one last item.

The department's reliance on contractors is largely invisible to the Congress, the public, and even DOE officials, themselves. DOE provides detailed information about official personnel in budget presentations to Congress, and maintains further information on a routine basis. Similar information about contractors is not presented to Congress, and [is] often not available in any organized form.

Equally important, DOE presents official documents with no indication that contractors have been used to prepare them.

Is there anybody in here who thinks that this is not a correct description of the problem with contractors in DOE?

The report that I read from was prepared in December 1980 by the staff of the Senate Committee on Governmental Affairs. What was true at that time about DOE's reliance on contractors is still true. That is a major problem, but I do not have a magic solution to it.

DOE has lost much internal expertise and talent in the past decade. Part of it is linked to personnel and pay issues, which Judy [England-Joseph] also mentioned. DOE's problems in this arena are similar to the problems of every other department of government, particularly over the past 10 years. We have lost good people because many such people don't want to work for the federal government at the pay rates that presently exist and under the working conditions they must presently endure.

We are trying to do something about it in the Congress. We have produced a Federal Pay Reform Bill, which I hope will be enacted this year.[2] I'm not terribly sanguine about the prospect for passage because any meaningful federal pay reform bill is expensive. Nonetheless, it has to be done if government is to halt and reverse the slide toward mediocrity and excessive dependence on contractors.

Some proposals for short-term fixes in this area are a little difficult to swallow because we are unsure as to exactly how they will work in

[2]Legislation making salaries of key federal positions more competitive with the private sector is contained in the Federal Employees Pay Comparability Act of 1990, which was included in the Department of Treasury, Postal Service, the Executive Office of the President, and Certain Independent Agencies Appropriations Act for Fiscal Year 1991 (P.L. 101-509, section 529).

practice. For example, when the Department of Defense authorization bill gets marked up this week, there will be provisions in it for critical pay positions both at Defense and DOE in defense programs, as well as a relaxation of the dual compensation restrictions for DOE and Defense.

Secretary Watkins [of the Department of Energy] has stated that he thinks there are 200 positions in DOE that should require critical pay. A person in such a position would get paid something on the order of $125,000 a year.

The debate over this issue invariably includes the statement that without establishing such positions we would be hard pressed to hire or retain scientists of international stature, people who could go out and write their own ticket elsewhere and need some incentive to work for or continue to work for the government.

So who would get these jobs at the Department of Energy? We asked for and received the result of an Office of Personnel Management survey of the various departments. In that survey, DOE named 35 positions requiring critical pay, including some that don't exist at the moment. They included the managers of all of the various area offices. They included the Assistant Secretary for Defense Programs, and his principal deputy, the job presently held by Victor Stello. Will politics or talent determine who gets a critical pay slot in the U.S. government? Time will tell.

But pay is not the only significant personnel management issue at DOE. There is also the problem of the corporate culture that John Layton mentioned. Despite Secretary Watkins' significant challenge to it, it is still a problem. We saw an example of it just recently during our investigation—which John Ahearne[3] knows all about, because he has been involved in it, too—of the risks of explosions at the Hanford site waste tanks. The managers at Hanford at the highest levels denied that there was any risk or that there was any documentation of such risk. That was just wrong, because we flushed out a report of the contractor, written a few years ago, indicating that possible explosions were indeed a concern.

That's another example of exactly the sort of behavior that we have been trying to deal with for many years now at DOE. And it looks like no

[3]Dr. Ahearne, a member of Panel 4, is Chairman, Advisory Committee on Nuclear Facility Safety, DOE.

matter what kind of reforms come in, we are going to have to deal with it for some period of time longer in order to restore public credibility to the weapons program.

Another management issue concerns priorities on spending and on research and development. Now, we hear a lot these days about global environmental concerns—global warming, the ozone layer, energy production, oil spills, and so forth. And there is rather explicit recognition on the part of people in DOE that one way of dealing with some of it is to try to do something about reviving the nuclear option in the United States.

So what is DOE going to do about that? They are going to build a new weapons production reactor giving highest priority to heavy water technology, which has absolutely no possibility of having any relevance to the commercial sector in terms of the next generation of nuclear reactors.

If the nuclear option is to be revived, we need a new generation of reactors because the acceptance of today's light water reactor technology is zero and is likely to remain so for an indefinite period of time.

Where is the technology development program for the next generation of reactors? It is minuscule. Of course there is still a fusion program. Is there anybody out there who still thinks that DOE's fusion program is going to be the answer to this problem? Where are the priorities? They seem misplaced.

"Should [the defense programs division] continue to be in the Department of Energy? Or should it be transferred to the Department of Defense?"

The next management problem I want to mention is an old issue—very old. But I think, in the light of what has happened in recent years, both nationally and internationally, it is an issue that needs to be revived, and it is the issue of where the defense programs division at DOE should actually reside. Should it continue to be in the Department of Energy? Or should it be transferred to the Department of Defense?

Now, we have gone around the barn on this a number of times in the past. When the Energy Reorganization Act of 1974 was passed, a study tried to decide whether the nuclear weapons program of the old Atomic Energy Commission should go to DOD as the Energy Research and Development Administration (ERDA) was created. The conclusion of that was to transfer the program to ERDA partly because we wanted to maintain civilian control over nuclear weapons. I confess that I never understood that argument because it always seemed to me that once the weapons were made, they were turned over to the Department of Defense anyway. So I wasn't sure where the civilian control was. It was through the civilian Secretary of Defense, to be sure, but certainly not through the Department of Energy, ERDA, or the old Atomic Energy Commission.

Then there was the related question of how you deal with the funding of weapons development. The Department of Defense never had to pay for it and has always gotten a free ride. As a result, the so-called stockpile memorandum really is more of a wish list than it is a list of what the requirements really are for weapons. The goals that are in the stockpile memorandum are never met.

Nonetheless, on the basis of an unrealistic goal, the Department of Energy or its predecessor agencies would go to the Congress and say, "Okay, here are the goals. Here is how many weapons we have to produce. Here's the amount of plutonium we need, high enriched uranium, tritium, and so forth. Now here is the money we need for that." No trade-offs were required. The Department of Defense didn't have to concern itself with trade-offs between conventional weaponry on the one hand and nuclear weaponry on the other. There didn't have to be any kind of integrated plan for how U.S. defense requirements would be met. We can't afford to do it that way any more. Especially now, with defense requirements going down and with energy requirements going up, there is a real need to revisit this issue.

The Starbird study was the next big study that was done. I think that was somewhere around 1976. We visited the issue again of whether defense programs should be in ERDA or out, and once again the easy decision was made to keep it where it was.

GAO at that time was asked whether it wanted to undertake still another study to take a look at this issue, this time from a congressional perspective. At that time, GAO replied that it didn't see the need to undertake another study, a third study, because there had already been two big ones that were both rather expensive, and the need for another one at that time was questionable. That decision was probably wise because nothing would have happened anyway at that time.

But it is now 14 years later, and the environment has changed. It is time, I think, to do another study—a deep, detailed study of this question. I think there could be a real debate in the Congress this time over what ought to be done, depending upon what that study shows. So I certainly think that is a management issue that really needs to be tackled.

The only other thing I will mention—and this sort of takes me full circle—is that John Layton is doing an especially terrific job looking at the San Francisco operations office. There is an Inspector General audit going on whose results thus far illustrate what is wrong in the Department of Energy with respect to how contracts are carried out.

For example, in the San Francisco operations office, $1.3 billion in personal property is being monitored by 1.5 staff persons. That is impossible to do. In addition, there are no industrial relations reviews by the San Francisco operations office on over $1 billion of nonmaintenance and operation contracts. Up to $200 million in defense program work for outside projects wasn't being monitored at all. There is a large amount of sole-source contracting going on to the tune of a quarter of a billion dollars. Who is looking at this?

There are nonstandard clauses in the contracts with the University of California that essentially do not allow Department of Energy monitors to say much about the way in which contracts are being carried out at the weapons labs. The excuse is that the labs have to have these special arrangements because one is not dealing with ordinary folk but with scientists. Well, as a former scientist myself, that's just an unacceptable reason for writing these kinds of contracts.

I hope John Layton's report on the San Francisco operations office, when it comes out, will spur the Department to do something about that. In any case, the Congress is surely going to take a close look at this.

Panel 4: Producing Nuclear Weapons Safely

Richard A. Meserve
Covington & Burling

I am going to describe in a very cursory fashion some work that I have performed with committees assembled by the National Academies of Sciences and Engineering to look at the nuclear weapons complex.

The Academies' efforts were started as a result of the Chernobyl accident. As many of you may recall, there were press reports at the time of that accident that one of our production reactors, the N-reactor at Hanford, shared certain similarities with the Chernobyl reactor. The N-reactor, like the Chernobyl reactor, is graphite moderated. There were concerns that an accident like the Chernobyl accident might be one to which the N-reactor was susceptible. As a result, the Secretary of Energy requested that the National Academies put together a committee to examine the issue.[1]

The scope of the study, in fact, ended up being far broader than the N-reactor. We looked at all of DOE's large reactors, or so-called Class A reactors. We explored a variety of management, safety, and environmental issues and issued two reports [through the National Academy of Sciences]—one in 1987[2] and one in 1988[3] —that dealt with a large number of problems that we felt the Department needed to confront in managing its reactors.

One of our recommendations was that the Secretary should set up an Advisory Committee on Nuclear Facility Safety. John Ahearne is the chairman of that advisory committee and has been involved extensively in examining issues relating to the weapons complex as a result.

After the issuance of the reports on the reactors, there was a follow-on direction from the Congress requiring that the Secretary ask the Academies to conduct a further study of the remainder of the weapons complex. Of course, as all of you know, the weapons complex embodies far more than just the reactors. That request ultimately resulted in the issuance of a report in December 1989.[4] I brought a copy of that along with

[1]This panel was the Committee to Assess Safety and Technical Issues at DOE Reactors, National Academy of Sciences

[2]Safety Issues at the Defense Production Reactors, Committee to Assess Safety and Technical Issues at DOE Reactors, National Academy of Sciences, 1987.

[3]Safety Issues at the DOE Test and Research Reactors, Committee to Assess Safety and Technical Issues at DOE Reactors, National Academy of Sciences, 1988.

[4]The Nuclear Weapons Complex: Management for Health, Safety, and the Environment, Committee to Provide Interim Oversight of the DOE Nuclear Weapons Complex, National Academy of Sciences, Dec. 1989.

me. This is the third in the series of reports that were issued by the Academies.

Our committee concluded that each of the facilities is so complex that it would be a trivial undertaking for a committee of experts to consume all of its time examining just one of the facilities. We attempted, therefore, to step back and to try to see the forest rather than the trees. We tried to draw conclusions as to how the Department should address the wide variety of challenges that it confronts in the management of the complex.

We looked at environmental, health, and safety issues; at management issues; and at modernization issues. Given the particular focus in recent years on the environmental issues, I think it might be best if I focused on our conclusions in that area. I would be happy to respond to comments or questions with regard to any of the other areas.

In broad overview, there are three main points that are important to understand about the environmental issues presented by the weapons complex. First, the environmental contamination is extensive. Contamination is pervasive at a wide variety of facilities. In fact, its extent is only today being fully defined. There are many instances, for example, where records of disposal operations are no longer available. The precise nature of the materials that were disposed of, or even the location of disposal, may not be well defined in many instances. A very large effort needs to be undertaken even to understand the extent of contamination.

Because the contamination is extensive, it is going to be very, very expensive to deal with it. Although I am not in a position to assess the cost estimates, figures in excess of $150 billion to $200 billion have been mentioned.

The second fact that is important to understand has to do with the nature of the cleanup problem. The common viewpoint—and the understandable viewpoint—is that, given the nature of the activities that are undertaken at these facilities, we must be dealing primarily with radioactive waste. In fact, many of the difficult problems relate to "ordinary" hazardous chemical waste. That is not to say that there are not radioactive wastes to worry about but that many of these facilities have chemical wastes that were disposed of in ways that, in retrospect, we have reason to regret.

Many of these facilities have been in operation since World War II. The contractors followed the practices of the time in their handling of the waste materials. They had particular focus and concern—understandably so—on the radioactive materials, but they handled the chemical wastes in the way that other industries handled them. The chemical wastes were of secondary importance. Just as private industry has a legacy of chemical contamination to deal with, so too must DOE address chemical contamination at the weapons complex. The problems that the Department confronts in dealing with its chemical wastes are not so different from the problems that many companies in American industry are confronting in connection with Superfund sites, RCRA cleanups, and so forth. Of course, the radioactive wastes have also proven to be more intractable than the contractors had suspected.

The third aspect that is important to understand has to do with the nature of these sites. For the most part, these sites are distant from populations. They are isolated, and hence, the contamination as a rule does not present any imminent or substantial endangerment of people.

Basically, we have time to think about the problem and to do things that are sensible. There is no serious concern that people's lives are in imminent jeopardy. This is not a situation where one needs to rush out and take action immediately; the response can be done thoughtfully.

Now, of course, it may well be that delay may make it harder to complete cleanup. As a result, I am not suggesting that we delay action needlessly. But the cleanup is something that we can address appropriately and thoughtfully.

The Academy reports also discuss a variety of recommendations and policy issues. I would like to just mention three. First, let me mention the importance of setting national priorities. A huge problem needs to be confronted at these sites, and the reality is that a limited amount of money will be available in any one year to deal with the problems. There are limits on what we as a nation can afford to spend. As a result, there is a need for priorities so that public funds are spent efficiently and cost-effectively.

It is my view that the Department's allocation of funds should differ in some ways from that required of the private sector. In the context, at least, of cleanup by private companies, the Environmental Protection Agency or another regulatory agency will initiate an enforcement action or threaten to initiate an enforcement action. The action or threatened action by the regulator becomes a driving force for cleanup. This same model has been followed with regard to the weapons complex as well, with important policy implications. The activism of a particular regional office can cause federal dollars to be channeled to the site where there is the most noise rather than to the site where there necessarily may be the most risk.

A need exists, it seems to me, for us to think through the national priorities in spending the scarce amounts of money that are going to be available at any one time. National priorities are necessary if we are to spend our funds reasonably and ensure that we are dealing with the cleanup problem in an appropriate way.

"There are great political pressures to go out and clean up everything."

The second policy issue that I'd like to mention relates to cleanup standards. The reality is that we cannot afford to clean up these sites to the level that the political process would demand. There are governors who suggest that if we leave radioactive or chemical wastes in the environment, we have created a "national sacrifice zone." There are great political pressures to go out and clean up everything. Well, we can't do it. We can't afford to do it. And, it is physically impossible to do it.

One has to set levels for the cleanup of these sites. The Academy Committee has suggested that such cleanup levels should be established through a risk calculus in which one looks at the risk that one confronts at particular sites and sets reasonable and appropriate cleanup levels on a site-by-site basis.[5] The alternative is to set some sort of a uniform standard that one would apply generically. The problem with the uniform approach is that such a standard must be established on an extraordinarily conservative basis in order to ensure appropriate protections in all the contexts in which it is going to be applied. You have to go through an analysis in which you make conservative assumptions as to exposure and as to the resulting doses.

The weapons complex sites are very different one from another. They are very distant, for the most part, from populations, and the risks, therefore, for some sites are vastly less than those for others. If we are going to spend our federal dollars in a reasonable fashion, it is important to fold the differences into the process of setting cleanup levels.

The third policy issue that I would like to mention is the other side of the coin from the cleanup problems that I have been discussing. We must

[5] The Nuclear Weapons Complex, National Academy of Sciences, Dec. 1989.

make sure as we continue to produce materials in these facilities that we don't leave a similar legacy for future generations to confront. The Department has an opportunity to plan for waste minimization right from the beginning. We must not only dispose of waste in an appropriate fashion but also use modern technologies to minimize the materials that have to be disposed of in one way or another.

That is hard for the federal government to do or even to think about, because waste minimization can require very substantial capital expenditures. It can offer long-term savings—but savings that are generated only over the life of the facility. Seizing such opportunities can be difficult for a governmental agency with a planning horizon defined by annual budget pressures.

But if we are going to avoid having the perpetuation of the kinds of problems that we confront today, we ought not to squander an opportunity for waste minimization.

Dan W. Reicher

Natural Resources Defense Council

Prior to becoming a senior attorney with the Natural Resources Defense Council, I was an assistant attorney general in the Office of the Attorney General in Massachusetts. I was a staff member of the President's commission on the accident at Three Mile Island and a staff member of the Hazardous Waste Section at the U.S. Department of Justice.

The Natural Resources Defense Council is a national environmental organization based in New York with additional offices in Washington, Los Angeles, San Francisco, and Honolulu. Since the early 1970s, we have been involved with the problems in DOE's nuclear weapons complex. We brought the first litigation in the early 1970s to force environmental impact statements on high-level waste cleanup at Hanford and Savannah River. We won a case in 1984 that established for the first time that DOE was, in fact, subject to the Resource Conservation and Recovery Act (RCRA), the principal federal hazardous waste management law. And we won a case in 1987 that overturned EPA's standards for the disposal of high-level nuclear waste.

We have also been involved in the publication of a number of books on the nuclear weapons complex. These include: U.S. Nuclear Forces and Capabilities, U.S. Nuclear Warhead Facility Profiles, U.S. Nuclear Warhead Production, and Soviet Nuclear Weapons. They are published by Ballinger. They are a nonpartisan, technical look at nuclear weapons both here and in the Soviet Union.

I'd like to commend GAO, not only for this fine conference but also for the outstanding work it has done over the years in exposing this very serious problem. I think in many ways GAO, with the assistance of the New York Times, can be thanked for finally having brought this critical issue to the attention of the American public and the Congress in a serious way.

I think the big issues for members of the public are, first, the safety of the reactors and the processing facilities that they live downwind and downstream of and, second, the cleanup of vast amounts of weapons waste that have accumulated since the Manhattan Project.

Mr. Ahearne will, I think, acquaint you with some of the issues involving nuclear safety, so I'd like to talk briefly about the issue of waste cleanup.

However you slice it, the nuclear waste cleanup problem is a huge one. Currently, there are estimated to be more than 4,000 sites where waste has either been spilled or disposed of. The groundwater at many facilities is contaminated at levels above federal standards. At some sites, contamination has spread off-site and contaminated drinking-water wells. GAO's own estimates put cleanup costs at $100 billion to $150 billion, which works out, by the way, to be roughly about $2 million for each warhead the United States has produced and more than we spent to put a man on the moon. At the Hanford site in [the state of] Washington, estimates for cleanup are in the tens of billions of dollars.

I think, along with the savings and loan bailout, this is really one of the great unfunded liabilities we face in the last decade of the century. But, as you move beyond this sort of headline, the DOE waste issues get a lot murkier. I'd like to try to shed a little bit of light on a few of those issues.

Defining Cleanup

The first issue is exactly what we mean by cleanup. Many have the notion that the cleanup of radioactive, hazardous, and mixed waste is something like cleaning up a spill off the kitchen floor—you wipe it up and it is gone. Unfortunately, I believe that cleanup will be a far more limited venture. I think the best we can hope for in many situations is simply to keep the waste from spreading any further. In fact, at the Savannah River site, DOE's preferred option for cleanup is what it calls "in-place stabilization."

Under this approach to cleanup, it is inescapable, I believe, that we will create huge areas that will be off-limits to the public in perpetuity—in effect, as Mr. Meserve noted, national sacrifice zones. The only question is how large these areas will be.

Cleanup Costs/Standards

The second issue is whether we can really get a firm grip on cleanup costs. My view is that we cannot at this point in time. First, we still don't know all the sites where wastes have been spilled or dumped. In just the last few years, the number of sites has risen from around 2,000 to more than 4,000. Contamination is spreading as we speak. The more that is learned about waste sites that have been identified, the greater the contamination problems often turn out to be.

And then there is, of course, the sleeping giant of decontamination and decommissioning, i.e., the cleanup of radioactively contaminated structures, buildings, etc., whose costs, I think, have been grossly underestimated and could occupy quite a large percentage of the overall cleanup budget in the future.

Another sleeping giant is the standards we apply, as Mr. Meserve mentioned. We don't really know what those standards are going to be, and that makes cleanup costs very difficult to estimate.

I'll give you two examples. First are the standards that will be applied to high-level waste and transuranic waste. These are standards issued by the EPA in 1985 that we sued over, and that were overturned by the First Circuit Court of Appeals in 1987. EPA is in the process of rewriting those standards. We won't see them for another year or two, and we simply don't know what they are going to look like. But their range could determine high-level and transuranic waste cleanup costs to a large extent. In other words, cleanup costs could vary over billions of dollars, depending on what those standards end up being.

Another even more recent set of standards that I think is particularly interesting is the so-called "below regulatory concern" standards. Two weeks ago the Nuclear Regulatory Commission (NRC) issued a final policy establishing a system whereby large quantities of commercial radioactive waste may be deemed "below regulatory concern" and disposed of as regular garbage without regard to its radioactivity. Lost in the press accounts are the implications that this has for DOE.

DOE is not governed by the NRC, of course. But in September of 1988, DOE amended its internal orders—the orders that govern much of its operations—to state that waste containing amounts of radioactivity considered below regulatory concern as defined by federal regulations—which could be those issued by the NRC—may be disposed of without regard to radioactive content. Huge quantities of waste that might otherwise have been attended to may therefore be left unattended under this policy.

Overall, my guess is that cleanup costs will rise substantially. In fact, the recently released DOE 5-year plan indicates an increase of over 60 percent in the cost of cleanup and waste management over the next 5 years versus last year's 5-year plan.

Cleanup Efficiency and Effectiveness

The third issue is the efficiency and effectiveness of cleanup—essentially, what will the taxpayers get for their $100 billion, $200 billion, $500 billion—whatever it ends up? The Congress and the public want efficient and effective cleanups where real contaminants are detoxified, destroyed, encapsulated, immobilized, or otherwise managed to reduce risks. But, instead, we may see huge amounts of money spent but few real physical results to show for it—what some call a low "dirt-to-dollars" ratio.

". . . we may see huge amounts of money spent but few real physical results to show for it—what some call a low 'dirt-to-dollars' ratio."

Lots of factors may produce this unfortunate result. The first is a lack of adequate oversight of DOE and the contracting community, both of which are substantially to blame for this legacy. Second is the tendency we have to study problems to death. Third is the failure to employ interim remedies that could slow or halt the spread of contamination in the short term while more permanent remedies are assessed. Fourth is the potential for fraud and abuse. We have already seen problems with U.S. Testing, Inc., and I think there are prospects for additional fraud and abuse in this program where so much money is at stake.

We also may see an overemphasis on exotic and complex cleanup technologies that may prove to be inadequate. Many DOE officials see new technologies as the key to driving costs down. Unfortunately, there is no firm basis in the Superfund program for this view. In fact, analysts of the Superfund program have found that new technologies tend to increase rather than decrease cleanup costs. So, as much as I would like to believe that new cleanup technologies will drive cleanup costs down, I am not convinced.

Cleanup Priorities

The fourth issue—and perhaps the most contentious of all—is how we set cleanup priorities, as Mr. Meserve mentioned. With over 4,000 sites, what do we clean up first and what do we clean up last? The quick answer, of course, is "worst first"; i.e., clean up first the sites that pose the greatest threat to human health and the environment.

As technically appealing as this approach is, however, it neglects a number of critical issues. It could mean that a decade or more could go by before we attend to entire facilities. For example, if we find that the greatest risks are posed at Hanford or Rocky Flats, we may not attend to other facilities for a long, long time. It is likely that the public will simply not accept this approach—especially the public living in the vicinity of the facilities where the cleanup is not taking place.

Second, the law sometimes sets different priorities than a purely risk-based system would set. Third, the Congress, through the budget and appropriations process, also may set different priorities. Fourth, states also have a substantial role in setting priorities—especially under RCRA. We are already seeing some of the states exerting that authority, and we are going to see intense competition among the states for limited cleanup funds. I think that is going to affect any kind of a purely risk-based system.

Finally, DOE's priority setting is part of the much larger problem of the cleanup of federal facilities, including literally thousands of Pentagon sites and those of other agencies. So lots of things are driving against the idea of a purely risk-based prioritization system.

Cleanup versus Production

The fifth issue is how DOE is going to allocate funding between cleanup and production. Since the start of the Manhattan Project, human health and the environment have always taken a back seat to weapons production. DOE's budget has long reflected this. In recent years, less than 5 percent of recent budgets have been devoted to waste site cleanup.

We must begin to strike a more rational balance between cleanup and production if substantial progress is going to be made in the restoration of the weapons plants. This will require a full and open debate on DOE's plans for the modernization of the complex—particularly in light of improving United States-Soviet relations and a declining defense budget.

DOE must be compelled to address fully and fairly a number of fundamental questions. For example, do we really need to build five new nuclear reactors—four modular plants in Idaho and one in South Carolina—to produce additional weapons materials at a cost that could well exceed $10 billion? Likewise, do we really need to spend around $1 billion on new plutonium processing capacity at Rocky Flats when DOE intends to phase out the facility?

We must also scrutinize DOE's recent attempts to include weapons-oriented activities under environmental accounts—to paint certain plants green, as it were. One example is the Plutonium Uranium Extraction

Plant (PUREX) at Hanford, which chemically processes fuel rods to produce plutonium. DOE argues that it must restart this plant, which has been closed because of safety problems, despite the fact that plans for a facility in Idaho, which would have further refined the product from PUREX, have been scrapped. Without this justification for the plant, DOE now argues that PUREX will help with the cleanup of Hanford by turning spent fuel rods into high-level nuclear waste for disposal. As a result, DOE proposes to shift the funding of PUREX to environmental accounts beginning in the fourth quarter of 1991.

However, it is not at all clear that processing fuel rods for disposal is the most environmentally sound and cost-effective way to prepare these fuel rods for disposal, nor is it at all clear that the plant will be operated exclusively for environmental purposes—i.e., to process fuel rods for disposal and not for weapons materials productions.

Unless and until DOE is able to make both of these showings, PUREX should not be funded from environmental accounts. DOE is also attempting a similar sort of green paint job at other facilities, including those at the Idaho National Engineering Laboratory and Rocky Flats. These must also be carefully scrutinized.

Role of the Public

The sixth and final issue involves the role of the public. Public support is critical to the success of any attempt to clean up the weapons complex. If such support is lacking, a robust and effective program can neither be created nor sustained.

There are two elements to public support. First is access to information; second is the opportunity for meaningful participation.

Regarding the first element, for decades secrecy has been maintained at almost any and all cost in the weapons complex. Today's crisis is attributable in many ways to this situation. While there are clearly legitimate national security needs, the plain truth is that far too much information is inaccessible, not only to members of the public but to state and federal regulators and decisionmakers.

For example, will our national security in the coming decade really be jeopardized by revealing the amount of weapons-grade plutonium in the United States stockpile or the number of warheads in our arsenal? Can we really expect a governor to accept blindly that development of additional plutonium processing capacity is critical at a facility in his state when the federal government won't reveal what is in the plutonium stockpile but at the same time the Secretary of Energy tells the Congress that the nation is "awash" in the material?

The absurdity of this situation is illustrated by a recent Freedom of Information Act case we brought against DOE to gain access to nuclear weapons testing data that our government has already shared with the Soviets. Think about it—independent U.S. experts not having access to technical data that our own government has freely handed over to the Soviets.

Even the new Defense Nuclear Facilities Safety Board created by the Congress recently to end the secrecy in the weapons complex has sought to shield itself from public scrutiny. The board has taken the position that it is subject to neither the Freedom of Information Act nor the Sunshine Act and therefore doesn't have to deal with the public the way all other multimember federal agencies have to.[6]

I should add that this is in stark contrast to Mr. Ahearne's Advisory Committee on Nuclear Facility Safety, which has been scrupulous in its attention to the Federal Advisory Committee Act and has made ample provision for public participation.

Along with greater access to information, DOE must also make a real commitment to meaningful public participation in the decision-making process. I think the Department has already made somewhat of a start with the 5-year plan where there have been good opportunities for public comment, public meetings and hearings, and the like.

But the real test will come with the two Programmatic Environmental Impact Statements that the Department of Energy agreed to prepare this past January. That agreement came in the wake of litigation brought by my organization on behalf of 21 other citizen groups in which we argued that the cleanup and modernization of the weapons complex would require such an impact statement under the National Environmental Policy Act.

[6]As a result of a decision in Energy Research Foundation v. Defense Nuclear Facilities Safety Board, 917F.2d 581 (1990), the board has issued proposed rules under which some of its meetings will now be open to the public under the provisions of the Sunshine Act, 55 Federal Register 53526 (1990).

We believe that this is going to be a real opportunity to assess in a full, fair, and public way the impacts of and alternatives to the current nuclear weapons complex. The impact statements ask and will hopefully answer some very fundamental questions about the configuration of the complex, various types of waste disposal, the sort of standards that ought to be applied, how we set priorities, etc. All of this we expect will be done in a very open, participatory way that will not only allow the public to testify and to have a role but will also involve other interested federal agencies, state agencies, local officials, and independent experts. We see this as an important watershed, and we are pleased that the Energy Secretary saw the light in the wake of this litigation and agreed to prepare the two Programmatic Environmental Impact Statements—one on cleanup of the weapons complex and the other on modernization.

We will wait to see, however, whether DOE makes the public meaningful participants, and whether DOE faces up fully and fairly to the critical issues that I have raised today and the many others that await the Department. I believe DOE's credibility with the public and its corresponding ability to carry out an efficient and effective cleanup will be seriously tested in this process.

Clark W. Heath, Jr.
American Cancer Society

It has been stimulating to listen to the last two panels and to this panel so far. It is an uncomfortable experience, too, because it recreates for me the very intense public hearings that we went through this past year in the Secretarial Panel for the Evaluation of Epidemiologic Research Activities (SPEERA), in which I participated. The panel was asked as an independent group outside DOE to advise Secretary Watkins on how he should manage the Department's epidemiology research activities. The panel existed for less than a year and held a series of meetings around the country. In those meetings I heard a great deal of the controversy that has now been reenacted here from different viewpoints.

During the SPEERA hearings, it was quite clear how complex this issue is bureaucratically and historically, especially in terms of its relationship to national defense. To consider how epidemiologic research studies should be managed in that kind of difficult and publicly anxious situation, I found to be a very trying experience.

We came up, of course, with a report on how the Secretary should manage these activities in DOE in the future. A lot of very good research has gone on in the past and continues to go on in DOE with respect to various risks to workers, and particularly with respect to ionizing radiation. We made 55 recommendations, and I think that DOE is now wrestling with how it can implement them. It is a complicated problem.

In discussing this presentation today with GAO staff, it appeared they wanted me to talk principally about occupational health risks, but I can't talk just about that. It seems to me that in considering health risks of the DOE industry—and that's what it is: a large, complex, multilocational industry—that one has to talk also about health risks, at least perceived health risks, to people who live near facilities, because of extensive concern about contamination both on-site and off-site around many of the plants.

So I propose to talk about both things—about the health research and health concerns that center around the DOE workplace, to be sure, and about the health concerns and problems that center around communities near many of these DOE facilities. The two topics share four common issues that are worth keeping in mind. One has already been emphasized by Dick [Meserve] in his earlier comments, which is that the health risks in these plants aren't just radiation health risks. In fact, in a practical sense, they are much more often risks from a variety of chemicals that are used in the production of weapons. The potential radiation risks are certainly there, to be sure, but the complexity of exposures to solvents, to asbestos, and to some special chemicals such as beryllium, needs to be addressed as well. These same exposures to chemicals may also have contaminated off-site locations and thus represent, at least theoretically, health issues with respect to nearby communities.

Secondly, exposures and health outcomes, to some extent, involve not just current events but past events, and so, to study them effectively is a particularly difficult matter. One has to dig back into records that, the farther back into them one goes, the more difficult it is to reconstruct what actually happened. That's not because things are particularly hidden but because it is in the nature of human records that they don't stay in one place in absolute perfect order year after year. So it is difficult to reconstruct past events.

"To answer health risk questions regarding exposures that are happening now, one has to wait 10, 20, or 30 years."

Where one is particularly concerned with health outcomes, such as cancer, which are delayed health events involving many years of latency, one is very much concerned about exposures that took place 10, 20, and 30 years ago. To answer health risk questions regarding exposures that are happening now, one has to wait 10, 20, or 30 years. Both at present and in the past, however, the DOE complex has maintained many records, regarding exposure to radiation as well as chemicals, that are useful for such epidemiologic studies. So both for communities near DOE sites and for the work sites themselves, health studies involve looking at past events as well as current ones.

The third commonality between communities and work sites in terms of trying to do research studies is the constant presence of great public concern as well as a perceived lack of credibility and openness, which creates a difficult atmosphere in which to examine what may otherwise be fairly objective matters. So communication, credibility, and public perception are issues that have to be dealt with forthrightly in both kinds of study.

The fourth issue that is shared between studies of potential community health effects and studies of potential occupational health effects is the current concern about the effects of low-dose ionizing radiation. Are current exposure guidelines that are set as safe for populations and for workplace groups actually "safe"? Or do we still have something to learn about what low doses do in terms of delayed health effects, particularly cancer?

Virtually all of the scientific evidence on this particular low-dose question points strongly to those health effects being negligible, and particularly in terms of cancer. The data from the Japanese high-dose exposure experience and from information regarding medical therapeutic exposures correspond well in terms both of risks at relatively high doses and of risk projections downward. Such projections predict that the average levels received by workers, or even at the limits of acceptable exposure, reflect risks in terms of cancer that are negligible. Ongoing studies of workers and of their exposure levels over years of working in nuclear plants—defense plants or otherwise—support the idea that projections from the high-dose exposures are, in fact, correct and that the health effects of such low-dose levels are probably negligible.

But we need more data. The SPEERA panel felt, and I continue to feel strongly, that the data that exist with respect to DOE worker populations—particularly going back into the 1940s and 1950s with some of the plants that have been in operation longest, such as Hanford and Oak Ridge [Tennessee]—represent extremely valuable information. Such data need to be very carefully assembled and carefully analyzed. And the analyses need to be done very openly—another issue which, of course, ran frequently through the SPEERA hearings.

When one considers health effects in the workplace, one has to think in terms both of acute health effects, which are usually related to rather high-dose exposures, and of delayed or chronic health effects like cancer, which are usually related to lower doses. For such delayed health outcomes, it is difficult to relate cause to effect because they involve long periods of latency.

Any modern industrial complex needs to have an occupational health program that addresses both acute and delayed health effects in its work force. Such a program monitors exposures that might lead to acute or delayed health effects, making certain through industrial hygiene measures that exposures are within current safe levels. If any abnormal health pattern appears in the work force, it needs to be studied intensely to learn as best one can what its origins are and to ensure that established safety levels are being observed in the workplace. Such workplace surveillance systems need to monitor not just ionizing radiation levels but the gamut of chemicals present in the workplace that may have adverse effects, as well as the usual physical hazards to which workers may be exposed, such as noise and injuries of various sorts.

Finally, a full-scale occupational health program should take into account the lifestyle patterns of workers—the health risks that they bring to the workplace. Are they smokers? Are they drug users? By taking such lifestyle risks into account, the program can evaluate workplace risks more effectively and can furnish medical care more aggressively.

At many DOE sites, many elements of a comprehensive occupational health program are in place, although to different degrees and in different forms. Programs, however, seem uncoordinated in terms of centralized communication and, hence, in terms of their ability to maintain operations that really function smoothly together. This relative lack of central coordination is not unexpected, I think, given that contractors run most of these sites and that the DOE management structure, as you have seen earlier today, is extraordinarily complicated.

So one of the strongest recommendations from the SPEERA panel was that DOE reorganize its occupational health program both centrally and at each site so that there is a standard core of worker health and exposure information collected, as well as a standard way of conducting surveillance, of communicating with and involving the public, and of having active follow-up when seemingly abnormal health or exposure events do occur—in short, so that DOE can develop a truly modern and comprehensive occupational health program.

With respect to community health, it is far less certain, despite allegations of environmental exposure, whether those exposures have actually exposed people at levels that present real health risk. To be sure, a great deal of concern exists in many communities that such truly hazardous risk exposures have happened, and people will point to clusters of cancer and groups of other diseases that, by their existence near a plant, seem to a lay person to fulfill the requirements of a cause-and-effect relationship. But, of course, such conclusions are in fact very hard to pin down. One has to be very careful in evaluating such health events, particularly if they are long latency or delayed effects, to be sure that there may be a reasonable basis for thinking there is a causal relationship.

This is an extraordinarily difficult area of environmental epidemiology, and I think the approach being taken at present—reconstructing exposures as carefully as possible in places like Rocky Flats and Hanford before proceeding to do full-scale epidemiologic studies—is entirely appropriate. Without precise information about exposure and dose, an epidemiologist is quite lost in this field and can really draw very few conclusions. But with good dose information, acquired in an open manner with full community participation, useful epidemiologic studies may be possible.

In the last 4 or 5 years in England, there has been a lot of concern about clusters of leukemia cases in children near nuclear plants. Sellafield is a nuclear fuel reprocessing plant on the west coast of England where much of this concern has focused. A case cluster in the vicinity of Sellafield led the British government to do a nationwide survey of childhood leukemia in relationship to nuclear plants in that country. That study, in turn, has led this country to do a similar study, the results of which are scheduled for release by the National Cancer Institute in mid-September.

The issue of community health effects became particularly intense earlier this year when a special in-depth epidemiologic study of the Sellafield cluster of childhood leukemia cases was released. That study found an association between risk of leukemia and paternal workplace exposure to radiation at the Sellafield plant. Four of the five cases showed exceptionally high cumulative levels of paternal exposure. While those levels were well within the present limits of safety as currently established for nuclear work practices, they raise certain fundamental scientific questions concerning low-dose exposures and require close scrutiny.

Thus far, the scientific community has been cautious in its interpretation of these British data, and I think that is appropriate. The issue, however, underscores the importance of continuously evaluating possible relationships between human health problems, and present and past occupational and community exposures at nuclear sites and in the course of producing nuclear weapons.

John F. Ahearne

Sigma Xi, The Scientific Research Society

Let me take as my starting point some comments made by Vic [Rezendes, Director of Energy Issues, Resources, Community, and Economic Development Division] in testimony to the House Armed Services Committee in March of this year. He was talking about the problems at the weapons complex, and he said

> These and other problems have been due, in large part, to DOE's failure to effectively manage the nuclear weapons complex. These management problems have included an emphasis on production over environmental and safety matters, shortcomings in DOE's oversight function, the absence of a specific strategic plan for addressing the modernization and environmental problems of the complex, an over-reliance on contractors, and limited technical staff to carry out departmental responsibilities.

Today we have heard a lot of those points reiterated. I don't disagree, but I do note that a few other people are involved other than just DOE and its predecessor agencies. The Office of Management and Budget (OMB), the White House, and the Congress all were involved over those years in acquiescence to the problems that led to where we are at the moment, and that was over many administrations. It wasn't just the current or the preceding administration.

In using those criticisms, I just want to provide a few recommended issues for GAO to examine. One is the proliferation of oversight and assessment groups.

My first observation is on a chart that Joe Hezir of OMB showed indicating five organizational elements normally involved in what is called "safety oversight."[7] All of the line offices are now setting up nuclear self-assessment offices. There is the Defense Nuclear Facilities Safety Board. There is the Advisory Committee on Nuclear Facility Safety, my committee, which Dick Meserve was instrumental in getting started. Then there are DOE's Assistant Secretary for Environment, Safety, and Health, with the associated Tiger Teams, and the Office of Nuclear Safety.

GAO has been urging oversight; however, there really is a question as to whether there are now too many oversight organizations. Do they get in each other's way? Do they overload the operator with too many responses? It is not unlike trying to do self-initiated work while the Congress keeps on asking you, "Why don't you do this? Why don't you do

[7] See also Environmental, Safety, and Health: Status of DOE's Reorganization of Its Safety Oversight Function (GAO/RCED-90-86BR, Jan. 30, 1990).

that?" The operational people in the Department have to do work some of the time.

Can there be enough competent people found to staff all of those offices? My committee is in the process of writing a letter to the Secretary of Energy saying unequivocally that we have found evidence to answer, "no," because the offices are being staffed, but clearly not by competent people. Now, clearly oversight is bad enough. Oversight by incompetent people is worse.

Is there any real role for my committee any more? We were initiated, realistically, in a last gasp effort by the Department to block Senator Glenn's effort to get the independent board [The Defense Nuclear Facilities Safety Board] set up. Although the DOE did it in response to the National Academy of Sciences recommendation, now that an independent board is set up, should my committee continue to exist?

And even though the independent board is now set up—and, as Dan [Reicher] pointed out, some interesting interpretations have been made about how it operates—I think perhaps GAO could revisit if it is really better than just having the Nuclear Regulatory Commission (NRC) do that.

Three of the big problems this new board is struggling with, in addition to the idea of how you can really trust holding a meeting with the public there, are (1) how to actually put people at sites and what would they do, (2) how to write regulations, and (3) how to deal with the licensee. I think the NRC, for all its faults, has worked out a lot of these problems.

The second issue is personnel. We have heard a lot today, off and on in various points, about the need for either higher pay or better people. GAO has mentioned the difficulty in getting enough competent people into the Department of Energy, and Secretary Watkins has urged special provisions to enable DOE to bring in sufficiently knowledgeable people. Is this really a DOE problem? Is it a governmentwide problem? Does it stem from something endemic in the culture that has been built up ever since the 1970s, when presidents started basically implying that working for the government is a lousy job and that only incompetents were able to do it? Or is it wider than that? Is it really the fact that highly competent people can make so much money outside?

For many years Secretary of the Navy, Admiral Hyman Rickover managed to convince some of the best people to work under terrible conditions for a tyrant, because he was able to convince them this was really important and it was something that they were going to be very proud of. That won't work for everybody in every place. Maybe money is really what is needed. But if that's the case, then I think perhaps GAO ought to try to point that out.

I noticed a wincing sigh in the room when Len [Weiss] mentioned the new provisional salary for these special cases of $125,000 a year. But realistically, if you are now talking about a $10 billion to $100 billion effort and you are trying to look at the best use of the nation's resources, is it unreasonable to pay the people who are going to try to run this—if you can get people who will do it right—a very high salary? In the long run it would save a lot of money.

The third recommendation concerns the rationale for new facilities. There is a cyclone of change sweeping throughout the world—certainly sweeping through Eastern Europe and the Soviet Union. How much weapons production is now going to be justified? The experience that I have had in the Rocky Flats area in Colorado, even with those people who are most supportive of the Department of Energy, is that they still want to know why this facility has to operate. Why do we have to rebuild Building 371? Why do we have to do all of this?

I don't think the Department of Energy has come up with a good rationale. A lot of modernization work is going on, but are the fundamental questions really being asked? Does the modernization study address these world changes? Should this kind of a study perhaps be on hold for a little while to see how these things shake out or should the study be redirected? Do we really need two new production reactor designs?

Len [Weiss] talked about the heavy water design. I think he is automatically saying the high temperature gas-cooled reactor design that was going to be built in Idaho is no longer a candidate. It might not be, but at least the Department is still going along as though it were. Do we need to?

Is finishing the WPPS plant perhaps really the most cost-effective solution?[8] A lot of studies have tended to indicate that, but most people shy away from coming out and saying that forthrightly because of the institutional problems, which is another way of saying that the politicians out in that part of the country are adamantly against having WPPS finished. Well, is GAO unable to take that up, to take the political heat?

Based on GAO's experience with the pitfalls of large defense acquisition programs, is the new production reactor program starting off correctly? I doubt it, but maybe it is. From what I have seen, it is questionable.

Fourth, we have heard a lot about the environmental cleanup. I ask, are the state agreements cost-effective for the nation? It is clear that these state agreements are something of great satisfaction for DOE managers. They have, by signing these agreements, defused great political heat in that local region and, in many cases, gotten the local environmental agency off their backs. But, overall for the nation, are they cost effective? And is it going to be a ratchet process? Will the next state be willing to accept less than the previous state? Why should it?

Does anyone care who pays or how much is paid? Are EPA and DOE working from the same set of rules and goals? Is there a national approach that prudently uses resources and involves the local population?

Secretary Watkins has said that DOE must use the lessons learned from 10 years of the Superfund program. Well, what are those lessons? One set of lessons is that we can waste billions of dollars.

There is a potential for that kind of approach, and I think you heard Dick [Meserve] talk a little bit about that. But unless some care is taken, there will be, in another 3 or 4 years, a set of GAO reports that are going to come out and say large amounts of money were wasted here and not much has happened. Or, to use Dan Reicher's interesting phrase, a low dirt-to-dollar ratio. That could very well happen. And, in fact, DOE might end up in a few years putting out a report called "Unfinished Business," for those of you who are familiar with the EPA report by that name.

[8]Dr. Ahearne was referring to Washington Nuclear Plant 1 (WNP-1), a partially completed commercial nuclear power plant that DOE has proposed acquiring and completing construction of to use as a nuclear weapons production facility. WNP-1 is owned by the Washington Public Power Supply System.

The national labs are another item. They perform weapons development, energy research, and basic research. The first, weapons development, is dying. The second, energy research, seems to be left to industry. What should be the roles of the labs—and, in particular, the weapons labs? Are they vestigial remnants? Are they pork barrel? Are they jewels? Or are they like aircraft carriers—very impressive, but too expensive to keep so many?

There is considerable concern about the future pipeline of scientists and engineers, and Secretary Watkins, in fact, has been one of the leading spokespersons on this. But are there going to be jobs for those? So perhaps the national labs are places to show that, yes, there will be jobs available.

But what are the roles of these labs? Over the last 15 years they have really been struggling. They have been oscillating between the Carter Administration and the Reagan Administration on going out to get heavily involved in energy conservation, dropping out of energy conservation, getting more into weapons work, getting out of weapons work, trying to now link up with industry for technology transfer. At some point someone has to be able to take an overview. The government has tried it, David Packard did a study for the White House Office of Science and Technology Policy, and maybe the GAO should do that.

The sixth item: Senator Nunn has proposed a strategic environmental research program, with the formation of a Defense Environmental Research Council, and for the Departments of Energy and Defense to work together on environmental issues. What would the implications be for the weapons sites cleanup program? Is [Speaker of the House] Tom Foley's Corps of Engineers provision a sound step or a pork barrel? What is GAO's position on that? Although right now it is just a minor activity—local Corps of Engineers working with Hanford—it actually has the potential of being the way that the DOE environmental cleanup is going to be done. GAO might consider taking a look at that.

As my seventh point, the first National Academy of Sciences study on the DOE weapons complex severely criticized the Department for the lack of a safety policy—that is, a clear set of standards against which the Department could measure its operations. Three years later, there still is no such policy. My committee has looked at and commented on versions ranging from a few pages to over 100 pages. Many of these drafts refer to an IAEA (International Atomic Energy Agency) document called "INSAG 3" (International Nuclear Safety Assessment Group), which was put together by an international team. Some of these drafts are obviously based on the NRC safety goals. Although there have been many drafts, there is no convergence. It is not that it has gone from a few to a hundred or from a hundred to a few; it has gone from a few to a hundred to a few and back to a hundred and has just oscillated. There is no convergence.

Recently, some members of the Nuclear Regulatory Commission's Advisory Committee on Reactor Safeguards (ACRS) dissented from an ACRS committee letter going to the Regulatory Commission on the approach being taken to developing certification requirements for the new light water reactors. I'll leave that issue to you, because I don't want to link it to what is happening in DOE.

What they said there was, "We do not wish to understate the difficulty involved in translating a safety goal policy into a workable body of regulation, but nuclear safety is not helped by letting that problem fester—the fact that it is difficult is no excuse for inattention. It is too much to expect regulation to be coherent and rational in the absence of an objective for that regulation."

My committee thought that pertained to what we saw going on in DOE. In fact, my executive director sent that ACRS letter out to the members of my committee. He said, "This summary statement is germane to the present state of nuclear safety policy development and nuclear safety order revision within the department. The committee was told at its May meeting in Washington by representatives of the Task Force on Nuclear Safety Directives"—this is a task force that Secretary Watkins set up to look at things like safety policy, etc.—"that further development of a DOE nuclear safety policy statement and a nuclear safety goal is on hold."

The focus of the task force's efforts, and therefore of the Office of Safety Policy and Standards, is on preparing draft revisions of 10 orders by September 1, in preparation for taking them through a rule-making process. A rather vague hope was expressed to my committee that a safety policy would coalesce under this order revision and rule-making effort.

In a more rational world, one might first establish both an overall safety policy and safety goal and then develop rules and orders consistent with the satisfaction of that policy in retaining those goals. That's an obvious job for GAO. Here is a clear charge by the Academy body—everybody agrees. Good idea. Necessary. The Department lacked it—still lacks it. It is not clear there is much progress towards it.

Another item: the majority of DOE's budget and its attention is on the weapons complex and on cleanup and modernization. Much as I find it unusual to be in total agreement with Len Weiss, I do agree on this one. I call it the "Emperor's new clothes" issue. Why should our weapons part be part of the DOE budget? Aren't issues of energy policy, energy development, and energy research as important—if not more important—for the Department of Energy?

When the Department of Energy was formed—and I was working at the White House at the time—the debate and the focus was on energy. It wasn't on weapons. It is now a weapons department. Any of you who have spent much time dealing with the senior levels of DOE realize it is a weapons development problem—cleanup, modernization. That's where the focus of the interest is. It has to be. That's where all the dollars are. That's where the huge future commitment, the unpaid bills, are sitting. I think that's an issue that GAO could well address.

We heard some reasons here from Joe Hezir of OMB as to why it wasn't a good idea. My experience of why weapons development wasn't transferred was a very simple one. If you took those dollars and transferred them to DOD, the Congress would say, "Look, here is this huge DOD budget and you are transferring this amount in. DOD could swallow it. It wouldn't be an add-on." That was the fundamental reason—at least as I saw it—why for many years it wouldn't happen.

I'm sure the same argument is going to be raised again if the DOD budget declines, but it doesn't make sense. And the one place where you now still have a bunch of technically competent people who are experienced in how to manage things—and, in fact, Admiral Watkins [Secretary of Energy] could get a lot of senior Navy people automatically—is if that program were in DOD.

What, as my next point, are the real hazards associated with the sites—past, present, and future? My committee has held public meetings around the country. It is very clear at those meetings and from the written submissions—and I think Clark Heath alluded to similar comments that he must have gotten on his committee—that a large body of the public is absolutely convinced that those sites are great health hazards currently and certainly were in the past. They are afraid, they are angry, there is an intense dislike of government officials—DOE, in particular. There is a disagreement with anyone who tells them that things aren't really that bad.

I saw, over a 6-month period, the bulk of the people speaking at the Rocky Flats facility go from strong support of Colorado state government to strong antagonism toward Colorado state government because the Colorado state government said we had looked at the measuring devices that were measuring the emissions from Rocky Flats and found that, yes, they were running correctly.

This is a serious problem, and I don't know how to address it. It is a combination of completely lost credibility, with good justification; a lot of history of lying, deception, hiding; a great fear of this mysterious element, radiation; and a great concern not about just themselves, but about very close family members. Adding all of those things together, it is a terrible problem, and I don't know what to do about it. But perhaps that is an area for GAO.

Another issue is the impact of the Congress. Has it been good, bad, or indifferent? Is the heavy congressional involvement a good idea or a bad idea?

There are other issues—contractor liability, all of the progress of that. High-level waste—should the Department look for alternatives? I disagree with what Ben Rusche [member, panel 2] said. It seems to me that trying to arm wrestle a state and essentially saying, "we've held a national lottery, and you lost so you get it," just won't work. It is the reverse situation with the competition for the Super Collider, but it is very similar in the sense that you get a lot of states willing to participate and to talk and discuss, as long as they believe they aren't going to get the site. No matter who does get it, there are still going to be all these kinds of problems.

Perhaps DOE ought to say that it is going to revisit and do surface storage until it can figure out a better approach to take.

On safety, which I gather some of you thought I was going to talk about—those problems have really been beaten for so long. They are there. There are problems of deferred maintenance, there are problems of the operating culture, there are problems of the fact that when you put up a security barrier to keep information from going out it also

". . . the big changes in the commercial world after Three Mile Island just never occurred in the DOE world."

prevents information from coming in. And the big changes in the commercial world after Three Mile Island just never occurred in the DOE world. Those people, for whatever reason, stayed completely away from learning about what had happened. Ideas about safety analysis, probabilistic risk assessment, going through worst case scenarios—all of the issues that the commercial world, by the early 1980s, had absorbed, understood, and was beginning to apply—seemed to be completely new when we got out into the world of defense reactors.

Panel 5: Opportunities for Energy Research and Development

Linda Cohen
University of California, Irvine

I will report today on the main conclusions from our book, The Technology Pork Barrel. [Linda Cohen and Roger Noll, to be published by the Brookings Institution.] We analyze government programs intended to promote commercial industry through the development of new technology: the breeder reactor program, synthetic fuels development, photovoltaic electricity development, the Space Shuttle, communications satellites, and the supersonic transport plane. Three of the case studies are authored by Jeffrey Banks, Susan Edelman, and William Pegram, whose help I gratefully acknowledge. I will focus today on our general conclusions and then summarize our recommendations for energy research.

Let me start with the economic justifications for the programs. Virtually all of the programs involved products or industries that were subject to market failures in the provision of research and development (R&D). The standard case for public investment in R&D says: because the ultimate product (new technology) is uncertain; because rewards accrue only in the long term; and most importantly, because inventions are often difficult to appropriate, the private sector will tend to invest less than is socially optimal. To rationalize targeted investments—those relating to a particular industry, rather than the scientific base of an economy in general—and to rationalize public projects rather than subsidizing private efforts, economists tend to look for particular structural features of an industry. These too existed in all the programs we looked at, with the possible exception of the supersonic transport.

First, the programs were virtually all tied to some special salient political feature. In the case of nonnuclear energy programs in the 1970s, it was the energy crisis and the issue of energy security, whose social import clearly fell beyond the usual concerns of private industry. The space shuttle program and the National Aeronautics and Space Administration's (NASA) satellite program in the 1960s were tied to the space race and involved issues of both national prestige and national security. Nuclear programs have always had special national salience, owing to the close ties between nuclear commercial technology and nuclear bomb technology.

A second source of market failure rises from the status of the targeted industries. In the energy field, the electricity industry is publicly regulated. While the petroleum industry is less regulated today than during the 1970s, evolving environmental regulations for both petroleum and coal create substantial uncertainties for producers of both fuels. Nuclear power is, of course, regulated at all stages of the fuel cycle. As a result, private research incentives are quite different from other more private industries, and a strong case exists for federal subsidies.

Finally, the third area of concern relates to the type of technological option. When investments are extremely large and "bulky"—that is, single projects require very large investments relative to other activities in the industry—the risks involved may be quite unacceptable for usual private efforts. This was the case for the energy programs that we examined. One has to be quite careful with this rationale. For example, while aircraft development is extraordinarily expensive, private companies have made such investments, literally betting entire company assets a number of times.

The energy sector is as subject to these failures today as during the period of large expenditures in R&D. I endorse the statement made by Jack White during our earlier discussions: clearly, we should be investing at the public level in strategies to deal with future energy problems and in R&D to expand the technological base for energy alternatives.

As those of you who are familiar with these programs know, the history of R&D commercialization programs is not a happy story. In virtually every program we looked at, the relevant departments either undertook or commissioned very involved cost-benefit studies both at the initiation of programs and periodically during their tenure. A factor common to all of them except for the synthetic fuel program was that the initial studies plausibly supported a straight economic rationale for the investment—that is, while some controversy existed, a reasonable case could be made that they would lead to commercial products.

Despite the initially optimistic cost-benefit studies, only one program that we examined—NASA's activities in developing communication satellites—achieved its objectives. However, that program was killed for what we believe were systematic conflicts with important political forces other than the advancement of commercial technology. We concluded that it was a victim of its success: because the technology was so valuable, it had the potential of restructuring the broadcasting industry. Existing firms in that industry worked systematically and successfully to curtail and eventually end the program in the early 1970s. This brings up the first political force that appears to be a problem for government

". . . technological options investigated by the government tend to be too narrowly focused and subject to premature cancellation."

R&D programs: public and private sector investments coexist with difficulty in the United States. As a result, technological options investigated by the government tend to be too narrowly focused and subject to premature cancellation.

The size and number of firms in a given industry depend in part on available technology. When products or services are most efficiently provided by firms that are large relative to the total market (e.g., advantages from standardizing nuclear plants and coordinating management and maintenance services), few firms may efficiently coexist. Alternatively, new technology can change the equation: if electricity is provided in a distributed fashion, the case for regulative monopoly firms weakens. Communication satellites are not subject to the scale economies that exist in fiber optic cables. In general, important new products change the optimal mix and size of firms in an industry, while which firms will ultimately benefit is uncertain ex ante. Democratic political systems incorporate existing industry preferences into decisions; hence, such efforts face extraordinary hurdles as government initiatives. In brief, many potentially useful commercial applications of R&D projects have distributive liabilities because they threaten established firms.

As a result, federal programs often appear too narrowly focused to meet their objectives. For example, coal synfuel programs in the late 1970s had, as the main objective, developing near-term alternatives to imported oil. Nevertheless, the DOE program concentrated almost exclusively on technologies that used eastern coal. The program derived from a small generic research effort in the Interior Department's Office of Coal Research, which, in the 1960s, had as a primary goal expanding eastern coal use. Because developing technologies that used western coal threatened the eastern coal industry, because opposition arose from at least some western states to rapid development of their coal resources, and because a politically viable coalition for synfuel development in the 1970s included the eastern coal interests, the DOE program constrained research activities to technologies that could use eastern coal. In fact, this constraint was at odds with its security mission. Such technologies are highly problematic and were thus poorly suited to rapid technological development. Not one of the pilot plans investigated by the Energy Research and Development Administration (ERDA) and DOE successfully demonstrated anything approaching commercial applicability.

One of the problems we identified in the case studies is that they tended to be subject to a "boom-bust" phenomenon. For example, energy research expanded dramatically following the energy crises of 1973 and

1979 and then contracted even more rapidly in the 1980s. One explanation for the phenomenon relates to the issue identified earlier: when programs identify particular products, they frequently run into political opposition, resulting in premature cancellation of useful research, as well as demonstration activities.

The case studies identified two additional reasons that research may cease prematurely when industry becomes closely involved in attempted commercialization. First, the reluctance of ideologically conservative legislators to become involved in private sector activities increases with increased private participation. Second, political saliency—concerns like energy security—declines for federal programs, for private adoption efforts may appear to resolve immediate problems. As a result, funding declines for research as well as commercial adoption activities. Current analyses of the federal light water reactor program, for example, conclude that the government probably scaled back its research activities too rapidly following the Power Reactor Development Program and adoption of the technology by utilities in the mid-1960s.

The tie-in of political saliency to major R&D programs is, we believe, a result of the general irrelevance of R&D to politics. Long-term R&D, at least prior to construction of prototype or demonstration plants, delivers neither the particularized benefits of major expenditure programs—like defense projects—nor visible benefits in the time frame relevant to reelection prospects of legislators. Lacking institutional support in the Congress, the history of the energy programs demonstrates poor preparation and, frequently, rapid contraction. When energy became a salient issue in the 1970s, the Congress did not have a convenient committee structure with which to deal with it. Existing committees fought for jurisdiction, and responsibilities became fragmented. The result was that a strong base of support for energy generally, and commercial R&D in particular, was never constructed in the Congress. This contributed to a spending competition between 1975 and 1980 that probably spent far too much on energy-related technologies.

Federal bureaucracies, as well as the state of the technology, were poorly prepared to deal with it: for several years, appropriations far exceeded outlays in energy programs, the most extreme example being the Synthetic Fuels Corporation. A rapid contraction followed the oil price decreases and the election of Ronald Reagan, who was in general antagonistic to federal R&D commercialization projects. Not only were demonstrations cancelled, but long-term R&D declined as subgroups of energy interests failed to coalesce around a smaller yet politically viable program.

Several key issues are involved in the history of energy funding around 1980. First, political salience follows a different, much shorter time horizon than that which is optimal for a coherent energy policy. Research required sustained efforts for efficiency. Second, the bundling of expensive demonstration programs—or more generally, development and technology transfer activities—with research responsibilities in both congressional oversight committees and DOE (and similarly for other agencies with research responsibilities) tends to work to the detriment of sustained research activities.

One problem, alluded to above, is that coalitions are likely to form that are opposed to commercialization efforts. Once formed, they can undermine research as well. Second, the relative political importance of late-stage versus early-stage projects typically means that when resources are constrained, the latter suffer disproportionately.

Cost overruns in big government programs, and in programs involving technological uncertainty, are well known, and I will not belabor their unfortunate cost history. The critical issue is that in virtually every program that we looked at, cost overruns and demonstrations were initially financed out of research activities within the same program. The Clinch River Breeder Reactor was originally projected to absorb 2 percent of the breeder budget. By the time Clinch River was cancelled, the remainder of the program had been cut back, and goals for different program components redefined, to the point that Clinch River comprised about half of what the government planned to spend on breeder commercialization. The space program's shuttle program similarly abounds with examples of cost overruns, resulting in cutbacks in space science and support activities.

In essence, large concentrated projects deliver "pork barrel" benefits: they yield short-run redistributive benefits to companies and individuals that receive contracts. Such individuals form powerful political constituencies that serve to maintain the projects (frequently for years after they make economic sense), to cause demonstration programs to rigidly adhere to initial specifications despite new information about costs or demand for the technology, and to redirect resources from less politically protected research activities.

Initial cost projections are frequently very optimistic, and ex post evaluations of demonstrations programs conclude that commercialization was premature. One reason for such optimism in the programs that we looked at was that they were proposed by agencies whose steady-state mission was largely scientific rather than commercial. Agencies with responsibilities for fundamental R&D are prone to pursue commercial applications projects at least in part on the basis of their technical interest, thereby giving insufficient weight to commercialization possibilities. Moreover, the narrow, less practical orientation of agencies with major responsibilities for fundamental R&D breeds technological optimism. Finally, a political saliency crisis promotes short-run responses. Because rapid response relies on existing institutions and project proposals are solicited from scientific agencies, an incentive is created to pursue strategies that are overly sophisticated from a technological standpoint. These factors contribute to both the pervasiveness of cost overruns and the attempts at premature commercial application.

The key lesson from our analysis is that commercial R&D activities should be institutionally separated from activities designed to enhance adoption of specific technologies by private industry. In our book, we discuss separation at both the legislative and executive level; for the purposes of this panel, I will focus on changes recommended for DOE, with the note that we recommend parallel shifts in the subcommittee structure in the Congress.

The collocation of nuclear and nonnuclear energy in DOE necessitates a short digression. If the premise is correct that an American presence in the industry is necessary for the United States to have maximal influence in controlling weapons proliferation, then a continued connection between defense and support for commercial R&D makes sense. Indeed, federal subsidies to keep the industry alive also would be justified. Whereas the logic behind the creation of DOE was that all energy technologies would be housed in a single agency to enable informed trade-offs, the special issues involved in nuclear energy create instead opportunities for log-rolling across industries and technologies that are not based on energy policy concerns. As a result, the continued (and indeed growing) absence of balance between nuclear and other energy technologies suggests that these activities are better separated, for example, by creating a separate agency with responsibility for all nuclear activities.

While commercial application projects are now relatively few, the Congress's photovoltaic program and President Reagan's clean coal demonstrations indicate that they are really a durable part of energy policy.

Our proposal then, would be to house such activities in a separate agency (say, similar to the Synthetic Fuels Corporation). Finally, a third agency would focus on energy regulation, energy policy analysis, and generic research on nonnuclear energy technologies.

Separation of generic R&D from applications ameliorates some of the problems discussed above. First, separation creates independent sources of technical knowledge and reduces the chance of a confused melding of technical and economic objectives. Technological optimism of narrowly scientific agencies could only infect commercial R&D applications projects if they succeeded in leaping institutional barriers. This is a less likely eventuality in a specialized commercialization organization because the natural constituency of the latter is developers and users of the commercial technology rather than scientists.

Furthermore, it separates those activities that are most susceptible to the vicissitudes of pork barrel influences and of crisis politics from the more fundamental objectives of expanding the technological base of industry, which is most in need of managerial flexibility and long-term policy stability. Commercial applications failures would not be financed out of R&D.

Finally, it maximizes the chance that commercialization decisions can be separated from ex ante decisions about the lines of research to pursue in generic centers, while most explicitly made dependent on the ex post products of research to expand the technological base. A clear separation of R&D and applications may enable R&D to be less narrowly focused. Thus, the separation is expected to contribute to both stability and breadth of the commercial R&D enterprise.

Separating commercial R&D from demonstrations and promotions has clear drawbacks. The two activities frequently involve joint costs and shared expertise. More generally, the synergy between commercially oriented research and commercialization may be so great that it needs to be taken into account at all stages of R&D. However, it must be stacked up against the theoretical and empirical support for the argument that the absence of such a separation increases the chance for overly optimistic and poorly managed R&D programs.

James L. Wolf
Alliance to Save Energy

I am with an organization called the Alliance to Save Energy. I always emphasize the Alliance because a lot of times when I am introduced people think it's the appliance to save energy. If we can figure out what that appliance is, then we can solve all our nonprofit funding problems and maybe the federal deficit, too.

Let me give you a little background about what the Alliance is. We are a nonprofit organization based here in Washington, D.C. The name Alliance is carefully chosen. We are an alliance of government, business, labor, and consumer leaders all focused on energy efficiency. We have always been chaired by two Senators; our current chairman is Tim Wirth [of Colorado] and our cochairman is Jim Jeffords [of Vermont]. We are bipartisan.

Our orientation has been energy efficiency. We don't like to use the conservation word any more, because that connotes freezing in the dark in Jimmy Carter's sweater.

We do demonstration projects, testing new technologies. For example, we tested new flame retention burners for oil furnaces. These were invented in national laboratories in conjunction with private industry. At the Alliance, we wanted to know if they worked in the field as they were projected to in the laboratory. We did field tests of the new technology in conjunction with private industry, in this case the oil burner manufacturers and weatherization programs. Those were a success. That technology is now standard in new oil furnaces. They save 18 percent of the amount of oil burned.

We also tested technologies that we have found were not a success. We tested some gas heat extractors to capture waste heat from gas furnaces. Those also looked very promising in the national laboratory tests. When we went out in the field, we found out that they don't work. I think that's an important lesson.

From a research and development perspective—I used to be with a government agency, the National Oceanographic and Atmospheric Administration, which had a lot of national laboratories as well—I think one of the things scientists emphasize is quite right. If every experiment that you are doing is a success, you are not experimenting enough.

I think that's a lesson for research and development. We shouldn't expect that every research and development project is going to be a success. Private industry will tell you that, and I think the same is true of government expenditures.

We at the Alliance also promote economic development through energy efficiency. We try to relate energy efficiency to the issues and projects that people care about today. I think that's very, very important.

We have tried to design home energy rating systems, which is a research and development challenge. When you buy a new home, you will then be able to tell whether or not it is an energy efficient one. Working with the mortgage markets, you will be able to get a better mortgage by buying that energy efficient home. We have worked very closely with Fannie Mae [Federal National Mortgage Association] and Freddie Mac [Federal Home Loan Mortgage Corporation] to institute this. They are very supportive of it. It is very interesting how there is tension between the mortgage markets, who say home energy rating systems are an energy problem, and the energy people, who say they are a banking problem. We are trying to bridge that gap. I think a lot of what research and development needs to do is to bridge the gap between the different constituencies.

And finally we are doing a lot of work on energy and environmental issues. We are focusing on what the true costs are of carbon dioxide reduction. Should carbon dioxide reductions be required because of global warming? How do the macro models we have incorporate energy efficiency? We find that the answer is that they don't do it very well. In fact, modelers have told us this.

Let me give you one brief example. Right now New York State is in the lead of reforming utility regulations. Typically, when a utility promotes conservation, the stockholders lose money. That doesn't make sense. So we're trying to reform utility regulations so the utilities' least-cost plan is its most profitable plan.

If you change regulation, that's a more efficient society. Unfortunately, the macro models that the Council of Economic Advisors uses can't cope with that. We've spoken with the Council's people about their inadequacies to cope with what we call "market enhancing policies."

Jack White and I spoke a little bit previously about our remarks today, and he said he was going to say in his upcoming talk that there's no silver bullet in research and development. I think that's absolutely true. There is no silver bullet to the energy issue overall. I am not going to get up here and tell you that energy efficiency is the solution to all of our energy problems. It is not. It is a very important component to it, but there is certainly no silver bullet.

"We have, in this country, no comprehensive approach to research and development . . ."

We have, in this country, no comprehensive approach to research and development, whether it be energy research and development or any other industry. I speak at and attend many other industry meetings. I think we learn, from the energy perspective, what their problems are. You'll hear the same complaints there. From a research and development perspective, there is no comprehensive approach in any industry.

Part of that, I believe, is the institutional structures that we have. Linda Cohen touched on some of that. Part of it, I believe, is the structure of the Congress—the infamous committee structure, the subcommittee structure—and how it approaches issues. Nobody steps back and asks from a big picture perspective where our federal research and development dollars are going. Does it make sense? My answer to that right now would be, "No, it does not."

I think the current Administration is trying to do a much better job of overviewing research priorities and asking the right questions as it steps back. So I applaud it for that.

Linda [Cohen] mentioned the energy linkages. I think that is quite correct. No one cares about energy per se. It is hard for me to come to grips with that when I am spending my life doing energy work. But no one cares about it. In some respects that's very proper. People do care about the environment. People do care about having affordable housing.

But when I say that no one cares about energy, let me say that the utility industry is learning that lesson. The better utilities—and even my friends at the Edison Electric Institute, which is on the Alliance Board of Directors—will tell you that utilities don't sell kilowatt hours anymore. What they want to sell is energy services. People care about lights, transportation, heating and cooling; but they don't care about energy itself. That has important implications for research and development.

I think Linda [Cohen] said that the title of her book was <u>The Technology Pork Barrel</u>. Maybe one of my complaints from the energy efficiency side is that we have never been given enough pork. I wouldn't say per se that big is always better—whether it be a super collider [Superconducting Super Collider] or the supersonic transport. Nor will I say—as some say—that small is always beautiful. I don't think either one of those statements is always truthful.

But if you do look at the bigger projects—and Linda [Cohen] went through some of them: the Clinch River Breeder Reactor, the synfuels plants, even some of the photovoltaics—we have had some disasters in this country from a research and development perspective. The bigger projects have tended to be less successful. But again, the bigger the project, perhaps, the bigger the payoff.

Energy efficiency being small and dispersed has had a virtue—a thousand flowers out there in the desert. If we grew 998 of them or even 500 of them, we may be doing pretty well. It is both a benefit and a problem that the industry is both very, very small and dispersed. I think that is an important problem with energy efficiency research itself.

But why have we had some of these big projects? I think Linda [Cohen] identified some of the reasons and how they were tied to national security or national prestige arguments. I also think that she didn't touch on one of the main reasons—aside from the political pork barrel—which is the clout of the industries arguing for the projects.

If you look at these industries, I don't believe currently that the nuclear industry in this country is among those that are underfunded. I don't feel, frankly, that the coal industry in this country is one that really can't access money. That happens to be a personal feeling. And we are neither antinuke nor anticoal at the Alliance. It is important to recognize that we work with those industries.

But where is the money in this country? Let's look at that and then ask ourselves, do these industries have particular problems accessing money? In 1987, the last year for which we could get Department of Commerce data, the energy supply industries —which is primarily the electric, natural gas, oil and gas drilling industries—consumed 11 percent of all the available investment capital in this country.

Every single one of those industries stressed how low construction was in 1987 because there was little oil and gas drilling and there was no new electric plant construction. Nevertheless, look at the amount of money they could access. I question whether or not that they could access, if they wanted to, money for research and development projects.

Why is it that those industries are the ones that are getting the research and development projects—whether it be clean coal, the breeder reactor, or whatever? I think that has a lot to do with where the federal dollar is going.

My perspective on research and development comes not only from many of the activities at the Alliance that deal extensively with industry but also two particular projects that we have done. Every year since about 1982, we have been part of the environmental community preparing an alternative budget for research and development. It is the alternative to the budget submitted by the Administration to the Congress.

It started, of course, in 1980 in response to President Reagan, who thought the trees caused pollution and that conservation was only somewhat worse than a tree. He thought, "Let's zero out all the efficiency research and development programs. We are going to continue these other research and development programs—but for conservation, the free market reigns."

That, from our perspective, was intolerable. It caused us to show why we need research and development on conservation as well as in these other areas. We're not saying we want to stop it in other areas.

We also work closely with the broadly defined or ill-defined efficiency industry. A few months ago we conducted a survey of the industry about what they thought of federal research and development efforts. The industry was very glad that we, one step removed from the Department of Energy, did this survey. It allowed several of them to be quite candid about their opinions of DOE research and development. We used some quotes in the report without identifying the source. The firms didn't want to be specifically identified because they were doing research and development with DOE. Someone who is doing research and development with the federal government said, "Well, you can almost say that if DOE is doing it, it must be bad." There's a lot of tension between what private industry thinks DOE should be doing and what DOE is doing.

But overall, what is needed from a research and development perspective is what I call "energy perostroika," new thinking on energy. It is 1990—it is not 1980. I think the Bush Administration, although we criticize it when we think it is wrong, is doing a better job in the research and development area generally. An important fact to remember is that efficiency is very high tech. It is not freezing in the dark. It is new motors, new light bulbs, and other new products.

I'll just remind you that, whoever is responsible for the GAO building, there are an awful lot of inefficient bulbs in this building. Not only do we have to invent the new efficient light bulbs, we have to use them.

The efficiency industry is very, very small and dispersed, which creates problems for research and development. It also creates problems for the delivery infrastructure for efficiency services.

Manufacturers of heating, ventilating, air conditioning—HVAC equipment—don't consider themselves in the efficiency industry. Some of the manufacturers manufacture only very highly efficient appliances. Others are what we call full spectrum manufacturers, manufacturing from the most inefficient product to the most efficient product. They decide which products to put their research and development money into for very different reasons. That makes it a particular challenge for the government on how to focus its research and development.

I first want to emphasize that federal research and development, state research and development, and state programs have to work on the efficiency side of the delivery system infrastructure. When your furnace breaks down—I don't care if it is the most economical furnace on the market—you do what everybody does. You open up the yellow pages and you call a heating contractor. How do you know if that heating contractor is very good or not? Will its employees know what the state of the art is in the equipment? Will you even know what to ask them? Probably not. If it's the middle of the winter, you want your furnace fixed; and if it's the middle of the summer, you're lucky if you can get somebody to fix your air conditioner in 5 days. So you take what you can get.

But that means that we have to concentrate from a state level on how to improve the delivery infrastructure for efficiency. That to me is very important research and development. It is not just equipment and technology. Of course, that is ultimately what we want, energy efficiency services. That is the important fact.

As I remind people in Washington, D.C., nobody in a policy role in Washington, D.C., has ever installed insulation, a furnace, or anything else. Concentrating on the delivery is a particular role for the state and local programs.

When we surveyed the efficiency industry, we determined three main findings on their perspectives on federal research and development activities. One, the need to expand support for demonstration and commercialization programs. This may have been a reaction to the previous 8 years under the Reagan Administration where all we did—theoretically, and I emphasize theoretically—was long-term generic research and development. There was no demonstration, no commercialization activities. The industry says, "That's very nice, but it doesn't really help us very much."

Long-term generic research and development in a purely public sense is very appropriate. There is clearly some private research and development that fits this category—AT&T (American Telephone and Telegraph) is a good example. In the old days, the Bell labs and others conducted great private research and development. Then the question is, what is the appropriate public/private partnership?

Cost-sharing is one principle that DOE has embraced—for the efficiency area as well as others. That is a particular problem for the efficiency industry, which is very small. It is a lot easier for the clean coal people and the nuclear people to cost-share. If you want cost-sharing, they can cost-share because they can access the money. For the efficiency industry, small and dispersed, that is frequently a problem. To the extent that you make cost-sharing a criterion, you often screen out the most innovative start-up firms.

On this point about demonstration and commercialization, we have to think through what we want from our energy research and development. For example, let's take the video cassette recorder, not an energy product per se. It was invented here in America and it is produced only in Japan. Do we care about that? I think many in the Congress do. We complain about Japanese products a lot. From an energy perspective—if all you are focusing on is energy—I don't care if the most efficient products are coming in from Japan as long as we are using them.

So clearly there is a broader concern than just energy, I think, from our Congress and from the Administration. That's what the manufacturers are saying. If you care only about energy, you don't care where it is manufactured. If it is Japanese, Brazilian, German, so what—if it is being used for saving energy here. But if you care about more than just the energy focus, then we have to start looking at commercialization and demonstration as part of research and development.

Let's examine the case of the ceramics industry. The United States has a good ceramics industry, and Japan has a good ceramics industry. There is a little ceramic rotor that can be used in turbo chargers. It is very, very light weight. Ceramics are much lighter weight than metal and much stronger than metal. Nissan in Japan, with the support of the Japanese government and Nissan Corporation itself, is now installing 6,000 of these ceramic parts a month in Japanese cars. They are testing them out, putting them in. They are very light weight, which improves fuel economy very marginally but eliminates "turbo lag." The Japanese ceramic industry is getting a significant boost from having a Nissan production line requiring 6,000 of them a month.

The American manufacturer, based in California, has succeeded in selling a grand total of 600 to General Motors. That was 2 years ago, and no American car manufacturer has bought any since. What the American manufacturer is saying is, "If you want us around in 4 years, 5 years, when everyone is using ceramic parts, either the federal government has to start helping us, or private industry in this country has to start changing."

One of the things we have to think about is to separate those problems that are energy problems, per se, and those that are more systematic—the failure of American industry to adopt products whether it is the video cassette recorder or anything else. Why won't an American car manufacturer use a technology like this?

Variable speed drive motors—again, invented here, used somewhat now in industry here, but Japanese manufacturers are putting them in washing machines. We are using them in heavy industry and nowhere else. This type of motor adjusts the load of the washing machine and uses less energy. Why are Japanese manufacturers much more willing to be innovative on product adaptation and use? I think that is an important part of a research and development challenge. Some of it is an energy research and development issue, and some of it is much more broadly focused. I find that our DOE does not really approach the issue in a comprehensive sense. I think Linda [Cohen] was trying to bring that out in her remarks.

Some of it is an energy problem, but some relates to our Department of Commerce and other departments. I think we are starting to do a better job of commercialization, but it's still not sufficient.

The second problem the manufacturers highlighted was the failure of the federal government to buy any of the products produced by research and development. We have the example here. If we have all these light bulbs, why isn't the federal government using them? The analogy I make is to establish a civilian DARPA (Defense Advanced Research Projects Agency). Clearly the largest research and development agency in the federal government is the Defense Department. Let's now have it buy the products we invent, as DARPA does for specific defense-related products.

Our Department of Energy is unique. It invests in everything and never uses any of it. That to me seems a little strange. The manufacturers have said, "If you want to start the commercialization process, use the product. If you think it's good, help us commercialize it and make a commitment to buy and use it."

Let's use the light bulbs as an example. When we met with Senator Wirth and a lighting manufacturer, the manufacturer said, "Look, there's an Air Force Base in Colorado Springs. If just that Air Force Base was buying the light bulbs, we would set up the whole distribution stream. Because we would have to have the warehouses out there so that the light bulbs would be able to go to Colorado Springs. Then we can get the bulbs into supermarkets so that homeowners and other people can use them."

One of the points of emphasis on commercialization is using the federal government as a test bed for new technologies in research and development. I am pleased, again, within the last few months, that somebody in the Bush Administration is starting to listen. They do have some new initiatives oriented toward federal energy management. Remember, the federal government is the largest energy consumer in the country, just in buildings alone. It uses $4 billion worth of energy in buildings, not counting ships, tanks, and planes.

The final point revealed in the industry survey was that DOE management is not very good. I am not talking about it from a political perspective, but just by looking at the management of the national laboratories. Industry has clearly told us, "We don't understand what a national laboratory is. What does it mean?" I think that needs clear definition and refinement.

Industry doesn't understand if the national laboratory is a competitor or a collaborator. Do we work with them or are they in competition with us? When do they cost-share? When don't they cost-share? What do they research? How do they decide what to research?

The people in the national laboratories will also tell you right now that their role is pretty unclear. If they criticized the federal government—and many people from the efficiency programs got up and criticized the Administration during the Reagan years—then they sort of got penalized by DOE. They were told, "Well, we're not going to give you any more research money because you're criticizing what we're doing."

I think we need a clear articulation of the role—particularly in the efficiency area of research and development—of a national laboratory. What is a national laboratory? These laboratories are now taking consulting contracts from utilities and others. Maybe it is appropriate, but we need a clear articulation of their role.

Where we put our research dollars is also interesting when one overviews research and development. Examine the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI), again, the industries that have money—EPRI representing the electric industry and GRI representing the gas industry. Most of our electricity in this country, almost 40 percent, goes to lights and motors. EPRI spends more money than DOE in some areas. EPRI does virtually no research in lights and motors, even though 40 percent of our energy goes there. So maybe that is a good target for DOE.

Why doesn't it do research in lights and motors? It does a little, but very little. The answer is quite clear—because it has no competition. EPRI and GRI put their research dollars where there is competition—gas versus electricity. So far, gas can't run a light bulb aside from decorative heating outside your home. Gas doesn't really run a motor. EPRI and GRI put most of their research into industrial process changes where gas and electricity compete, and HVAC equipment where gas and electricity compete.

Competition is driving research. It also drives efficiency. They are competing in many respects on efficiency criteria, which is good. But I also think it is important to note—because many DOE projects cost-share with EPRI and with GRI—that just because they have the money to cost-share does not mean it should be a high priority federal project.

We should start looking at where our energy is going and where the opportunity is going and not just where other people are willing to put up the money, because their view of the appropriate research market is very skewed.

I'll take a brief look at the current federal research and development budget—and it doesn't make sense—and ask, "Are we trying to meet the energy challenges of the 1970s or the 1990s?" I think the issue is that we should decide to focus research where issues like energy, the environment, and the economy are complementary.

The Group of 7 [Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States] meeting is underway today. Germany, as you know, wants to reduce carbon dioxide emissions by 25 percent.

Once a month I have a Japanese delegation coming through my office. Japan views global warming as an export opportunity. The United States views global warming as a threat to the U.S. economy. Japan is saying, "Look, U.S. energy prices are low, third world prices are higher, eventually we will have to reduce carbon dioxide emissions. How are we going to do it?" It is going to be photovoltaic technology and renewable technologies, and it is going to be efficiency technology.

In the lighting area right now, for example, the General Electric (GE) bulb that we at the Alliance are promoting—the compact florescent—is a Panasonic bulb. GE just puts the name on it. It is made in Japan. It is not a GE bulb in some sense. GE doesn't manufacture it here. I think we have to start looking from a research and demonstration perspective in which the economy, the environment, and energy are complementary. I think we are going to find that it is most often in energy efficiency.

Particularly with the globalization of world markets, we have to emphasize efficiency more. Otherwise, our manufacturers are going to be producing air conditioner equipment, lighting equipment, motor equipment that won't sell here and won't sell overseas.

Remember the Japanese car. They started their significant penetration of our markets because of fuel efficiency. That's when they first got their market niche; right now, it is better quality and many other things as well. But if we don't start producing the products that will be demanded worldwide, we won't have the money to fund the research that we need.

Briefly, I'll review the current DOE budget. I think people know the numbers. Conservation only gets 9 percent of the pork. Obviously I am being facetious. I don't think that's sufficient. Renewables get 6 percent. Clean coal gets 21 percent. Fossil energy gets 20 percent. Nuclear fission gets 28 percent. Nuclear fusion gets 16 percent. The nuclear part is all civilian; I'm not counting the defense component.

I want to contrast that with 1980—not to say that was the good old days, but it was pre-Mr. Reagan. Conservation at that time got 10 percent instead of 9 percent. That was no great difference. Renewables at that point got 22 percent, significantly more than the 6 percent that they're getting now. Clean coal was not yet invented, so it got zero. Fossil energy got 22 percent. Nuclear fission was getting 33 percent and nuclear fusion 13 percent. So there has been a reallocation. Conservation is about the same. Renewables are down drastically. That has all gone to clean coal, and a little bit out of nuclear to clean coal.

In the alternative budget prepared by the Alliance and the environmental community, we didn't really change the allocation. Right now we recommend a conservation program budget of $285 million—the fiscal year 1990 budget was $195 million. It would be allocated to the buildings, transportation, and industrial areas.

Does this make sense? Let me just say that Linda [Cohen] went through a long history of technology failures. In conservation, they have had some astounding successes. We have had failures, too. Linda said that programs were terminated too quickly in fear of commercialization. In the conservation area, we found frankly that no one is willing to turn off the spigot. The managers don't make the hard decisions saying, "Look, this project's not going to work. Let's change it and change the research emphasis." They don't make the hard decisions because a lot of those people, frankly, got their Ph.D. in some arcane area and want to research it for the next 47 years. We need managers of DOE who have enough judgment and advice to say, "This is a dead end."

But to showcase a success, let's just look at the lighting area. Electronic ballasts are now permeating the market. DOE invested $2.7 million—not a whopping sum—in electronic ballasts. When they first went to the major lighting companies, none of them were interested. A classic case. Big companies, frankly, were not interested. "Hey, we manufacture the stuff now. We don't see any research challenge or need for it," they responded.

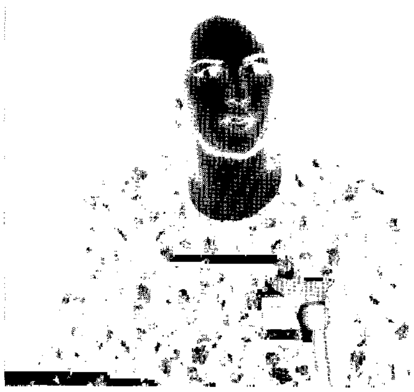
What happened is that several of the very small lighting companies became interested. DOE invested the money—$2.7 million—and the electronic ballast was made. Who started commercializing it? The Japanese. Now American manufacturers are picking it up. It was 1 percent of the market in 1985. It is forecast to be 50 percent of the market in 1995. How much money is it saving? Most of the manufacturers will say that the DOE investment advanced the commercialization of this product by at least 5 years. You advance the commercialization 5 years, and you will have saved the U.S. economy $24 billion in energy costs for a DOE investment of $2.7 million.

So I think we have had some notable successes. And there are others in the conservation area. We have had very good successes. Let's pursue these types of programs where we have complementary goals between the economy, energy, and environment.

Linda [Cohen] points out that commercialization and demonstration need to be done. I think they should stay at DOE. During the debate over elevating the EPA to cabinet status, there was discussion among the environmental community—"Should the conservation and renewable part of DOE go over to the EPA?"—because no one in DOE cares about it. That is the perspective of conservation in the environmental community.

My answer to that was, "no." I said that it was an energy source and should be treated as an energy source. But this is some of the frustration that people have with the way that the research and development budget is constructed. There may be merit in terms of looking at the issues that people care about and organizing research that way. Maybe the energy housing work should go over to the Department of Housing and Urban Development—if Jack Kemp can clean up the scandals—the environment work to EPA, or whatever. I think that is perhaps an extension of what Linda [Cohen] suggested. I don't think it is a good idea, but it is something that GAO may want to look at. Somehow, we do need to forge better linkages between the research that is being done and the true issue that is being worked upon and concerns people.

Cherri J. Langenfeld
U.S. Department of Energy



I will focus on some of the initiatives in the Department of Energy today that might address some of the many concerns that have been expressed.

I would like to start out by saying that I think Secretary Watkins; the Deputy Secretary, Henson Moore; the assistant secretaries; and the entire management team at the Department clearly recognize and acknowledge all of these issues that have been raised—the problems of management of the Department, the problems of managing the laboratories, the problems of setting research and development priorities, and how you go about doing that.

So I would like to focus on a couple of the management-related initiatives in the Department of Energy, and I am going to start with one that I think not enough people recognize as a management initiative. That is the National Energy Strategy. Before everybody starts chuckling about it, there are two components to the National Energy Strategy. One is the product that will be produced to comply with the national policy plan requirements. But the second component—and the component that I think is having a meaningful impact in the Department and across the Administration—is the process that we are using to develop the National Energy Strategy and some of the features of that process that do make it different and start to give us some ideas on how to improve setting research and development priorities as a federal government.

The National Energy Strategy process began almost a year ago. During most of the last year we have been gathering extensive amounts of information about a wide variety of subjects in the energy field as well as the technology field—research and development, technology transfer, science, education, math, and so on.

During that information-gathering phase, we held 15 public hearings; something on the order of almost 400 witnesses testified before the executives of the Department. We received over 1,000 written submissions, something on the order of 12,000 pages of written testimony, letters, and so forth. We had the national laboratories prepare white papers on some specific subjects including energy technology for developing countries, which is an area, again, that the Department has not focused heavily on, but in which there are some opportunities that we are interested in exploring further.

All of that information was compiled into what I'm sure most of you have seen, the "Interim Report on the National Energy Strategy." This report really only reported on what the public—in this case the public is represented by various individuals and groups, including the Alliance to Save Energy—feels that the Department should be doing or that the federal government should be doing to address energy and environmental issues.

I think some of the unique features—in addition to our going well outside the Beltway for input in developing this strategy—of the report itself are the following facts: number one, environment is stressed as a specific and directly related energy concern. While it is treated in a separate chapter, it is by no means treated as a separate issue. Environment is part and parcel of developing an integrated energy strategy, as is the economy.

Another key feature is—I think for the first time—that the Department has placed a significant emphasis on the importance of the foundations that enable us to deliver on any research agenda that might be developed by the Department. This includes the very important emphasis on math and science education. I'm sure many of you have heard Secretary Watkins state his commitment to this—particularly to kindergarten through grade 12 education. As we solve some of our energy and environmental problems, many of the solutions will require much more advanced technology. Even our factory workers have to be technically more literate than they have in the past to work with computers or robotics, to handle statistical quality control to be more competitive, and a whole variety of issues associated with the education element. And that is a very important component of the National Energy Strategy.

Another important component is a focus on the basic science research that the Department conducts as an underpinning to many of the applied energy developments that are of interest to our economy.

And finally the third area—which is the first time that it has been elevated to this level in the Department—is the issue of technology transfer. That is the area that I am primarily responsible for in the Department. How do we get the research and development that is funded by the taxpayer into practical application? We are grappling with many of the issues that both Linda [Cohen] and Jim [Wolf] have raised this morning about how to do that.

There were something on the order of 700 independent options reported in April [1990], many of which represented some aggregation of common options.

The report describes options ranging from "no more nuclear" to "lots more nuclear"; from "no more coal" to "lots more coal"; from "lots more energy efficiency" to "let's just let the market work." It is all in there. We did not try to sort it out or prejudge what the conclusion would be.

Out of that first report, however, we started to get some clear messages. I think they are already reflected in some of the changes occurring in the Department. One of the clear messages is that energy efficiency is an important component of the energy strategy. The Conservation and Renewable Energy Office has been reorganized, and its budgets are being increased to reflect that renewed commitment. We are also participating in the program referred to earlier that is looking at energy efficiency improvements for federal buildings.

So there are a number of new initiatives resulting even at this early stage. Another area, again, that clearly came out, was the importance of all the foundation areas. We have in the Department—which I'll talk about in a minute—another initiative focusing specifically on technology transfer.

What we are trying to do now is sort through all of these options. It is not an easy task. We have to do it in a way that we can present some possible strategies to the President that will help to mitigate the rise and fall of priorities from administration to administration, and even changes within an administration.

So the National Energy Strategy is an attempt to take a longer term view of the interaction of these issues and an attempt to educate the public and other members of the Administration and of the Congress on what the relevant trade-offs are that we have to deal with and how complex they are. And we are working through a series of departmental groups as well as interagency groups through the Economic Policy Council to evaluate the options and determine which of those options, in fact, can contribute the most to our energy and environmental future with the minimum amount of government intervention in the process.

Our goal is to present the cabinet members and the President with a narrowed slate of options by late this fall. The President then will select, based on the advice of all of his cabinet officials, those options that he feels are appropriate to support in his Administration. Then, come March or April [1991], the National Energy Strategy itself, the first version, will be published.

But what does all this mean in terms of the process inside the Department? Well, there have been a lot of interesting things happening inside the Department as a result of all this. First of all, all of the DOE staff have been forced to talk to a wide variety of constituents, people they might not normally have talked to. We respond to nearly every letter, we entertain every suggestion, and we try not to prejudge whether it has merit or not. I think, for many people outside DOE, this represents a change in working with the Department of Energy.

We are also seeing an increased interaction between programs in the Department of Energy, such as in the technology transfer arena. For the first time, we have had defense programs tied into a full intradepartmental team of people to focus on areas of common interest, the technology transfer issues that affect all programs. The level of participation and the openness with which defense program staff have participated has been unprecedented for the Department. The same is true for the Nuclear Energy Program. So we have seen an increase in interaction, an increase in communication, and an increase in an understanding of the issues and of the other programs.

We are also involved in developing a strategic planning initiative, not unlike what you are involved in here today. The Department has always responded to the normal annual planning processes, the annual budget processes. But we have not ever tried to integrate departmental planning into a long-range comprehensive strategy for the Department of Energy. That initiative cuts across, again, not only energy components but also the defense components and takes a look at the Department as a whole and the management issues associated with it.

So the initiative is evolving. The long-range vision is that we will be able to use some of the broad policy guidance that will come from the National Energy Strategy to help DOE develop more effective strategic plans for the programs, for the Department, for the laboratories, for the operations offices, and for all of the members of the DOE family. That in turn will help drive the budget process. We have already, in the fiscal year 1991 budget—which I believe all of you have copies of—started to reshape the budget according to the topics contained in the "Interim Report on the National Energy Strategy." This has helped us take a look at how the dollars are currently allocated between energy efficiency, supply technologies, and building foundations and see if that allocation fits with the picture that is beginning to evolve for the long-term National Energy Strategy.

So that's one initiative. The second initiative has to do with a more specific application of technology transfer. I think it has some relevance to the comments that we've heard already this morning. Regardless of what research and development we eventually pursue at the Department of Energy, whether we develop the plan and it gets approved, whether the Congress develops it for us, or whether other players tell us how much money we can spend on what—regardless of what research and development plan finally evolves—our goal is to make sure that that research is in fact used by somebody.

In the case of basic research, we certainly want it to be used by other researchers, by industry, by people who will take that basic scientific knowledge and push it into the next frontiers of new technology development. In the case of applied technology, clearly the use has to be by industry and by consumers. In the case of demonstration programs, again—if we are going to support such demonstration programs—we have to really look at how to more effectively ensure that the technology in fact transfers and does not end up as just one more form of government intervention in the market.

We have, since last November [1989], been involved in the implementation of an act called The National Competitiveness Technology Transfer Act of 1989, the NCTTA. It amends the Stevenson-Wydler Act and does a couple of things. On the surface, it does not appear to be very significant. It essentially extends existing authorities of Stevenson-Wydler to DOE's government-owned, contractor-operated laboratories.

But it also has a single statement in it that has some fairly powerful ramifications for the management of the Department. That single statement is that technology transfer is a mission of the laboratories, including the defense laboratories.

The same bill that authorized the NCTTA also amended the Atomic Energy Act to say that technology transfer is a mission of the Department of Energy. To have it stated in so many words is new. While we have pursued technology transfer in the past, we have not approached it as a primary mission of the Department. But I think, as Judy England-Joseph [of GAO] said in her opening comments, it is clear that the primary policy lever that we have as an agency and as a federal government is research and development for affecting the energy future. If that is the case, then we clearly need to look at the issues associated with technology transfer as a mission.

What that has meant for DOE is that we have taken on the implementation of the NCTTA to mean more than just responding to the minimum requirements. We have relooked at our management of the technology transfer process, relooked at what it takes to promote the commercialization of technology—not whether to commercialize. That is not the federal role or the contractor role.

It is the role of industry to commercialize. Our role is to promote it, to facilitate it, to find ways to bridge that gap between where we have traditionally left off with research and development and where industry has been prepared to pick it up. Again, through the National Energy Strategy, we received a number of suggestions on how to accomplish that. A number of successful programs in the Department were identified that we can build on, such as the Super Conductivity Pilot Center approach and now the new authority to use cooperative research and development agreements.

So we are working our way through a very complex implementation process, relooking at every policy in the Department. I would like to just briefly comment on some of the major policy issues, some of which I think will be of interest to GAO—in fact, many of them I think will be.

First and foremost is coming up with a philosophy of operations for technology transfer for the Department of Energy. Again, for the first time, we are developing a clear statement overall of what technology transfer means to the Department and its other missions. With that comes the issue of what role DOE headquarters plays. What roles do the field offices play? What roles do the laboratories play in managing that process? How much do we decentralize? How can we safely decentralize it and still exert the appropriate management oversight of the process to ensure that the taxpayer is getting a fair return for his investment?

Other issues include partner selection. If we are now going to focus on U.S. competitiveness, what does that imply about how freely we make the information available? What kinds of licensing approaches do we pursue? How do we ensure that we select those partners consistent with our international obligations? How can we facilitate the process by issuing more class waivers and giving the contractors more authority to negotiate rights with industry but, again, without losing control of the benefits that the taxpayer has invested in?

Sources and uses of funds is a very, very big issue and one that we are deeply involved in, just trying to define terms. What do "technology maturation" or "readying a technology for transfer" mean? Where do you stop? What is appropriate and what is not? Where does the money come from? Do we pursue a line item or do we pursue a tax on programs by using overhead? Do we use both? Do we use them for different functions?

So we currently have several teams working. There is a headquarters project team that is looking at many of these larger issues, and there are field teams looking at issues associated with outreach. How do we let industry know what is available?

Yesterday, I participated in a conference that the Department of Commerce sponsored on biotechnology. It was fascinating. There were about 60 people from the biotechnology industry who came to the conference to hear what four agencies had going on in the research arena. One fellow walked up to me after the DOE panel and said, "You know, I came because I was interested in what Agriculture was doing. But I found out that what I needed was at Energy. I need to talk to this guy." So we have to find more ways to let industry know what we have available and to do that in a way that the process happens quickly.

"This issue of technology transfer as a DOE mission opens up a whole new world for us . . ."

Conflict management is another major issue, individual conflict of interest and, also, organizational conflict of interest. This issue of technology transfer as a DOE mission opens up a whole new world for us in trying to deal with how we balance it relative to other mission priorities of the Department.

Evaluation and oversight—what are the processes that we have available? How can we improve them? How can we use them more effectively? What new processes do we need? This includes the institutional planning process that we use at the laboratories and our own appraisal process through the operations offices and through headquarters. It includes the audit process, accounting procedures; and again, we are relooking, expanding, building, and not taking anything as sacred in this program to try to revitalize it.

So we will be very interested in the outcome of your sessions here because I think the questions we are still wrestling with are the same questions that you are asking yourselves.

I think the first two panelists raised a number of the issues. I didn't want to repeat those. I hope that I've raised some additional considerations and at least, if nothing else, communicated that the Department of

Energy is aware of the problem. We don't have all the solutions. We are looking for support, assistance, help, advice, and any good ideas. We eagerly await the outcome of your deliberations and your planning process.

Irvin L. (Jack) White
New York State Energy Research and Development Authority

My assignment is to speak about energy research and development (R&D) from the state perspective, more specifically about how the federal government, in particular DOE, can assist states in conducting successful R&D projects in such areas as energy efficiency.

In what follows, I speak only for myself and not for New York State. What I have to say is based on my personal observations and experiences during the past 20 or so years, which includes university teaching and research as well as service in both the federal and New York State governments.

Planning

One of the most important things DOE can do to help the states is to complete the National Energy Strategy now in progress. As the lead federal energy agency, a major role for DOE, one ignored for much too long, is to lead the nation in reaching at least a majority view as to what our national energy objectives are. Under its current leadership, DOE has initiated a process for doing this.

In this process, DOE is to be commended for reaching out to hear from a broad audience and a variety of interests. DOE's interim report summarizes the multiple points of view its various regional panels have heard. I look forward to the next step, an actual energy strategy report, one that will state clear objectives to guide DOE's energy R&D planning. This kind of product will make it much easier for the states to work with DOE, both with regard to energy policy issues and energy R&D. (I just hope that all the federal agencies involved can agree on a meaningful product.)

Resources for energy R&D are scarce. Consequently, it is essential that these scarce resources be used wisely. An essential step in minimizing waste is to develop a common understanding within the energy R&D community of what the high priority energy R&D needs are. We all need to be working from the same map and with a clear understanding of what each other is doing.

During the past decade, the states have been pretty much on their own in this regard. In New York, we have a well developed energy R&D planning process.

Our R&D planning is guided by a state-level equivalent of a national energy strategy. As I said in my introduction of this panel, energy

"One of the most important things DOE can do to help the states is to complete the National Energy Strategy . . ."

doesn't stand alone. In explicit recognition of this, New York's Energy Plan is now developed jointly by the State Energy Office, the Department of Environmental Conservation, and the Public Service Commission. Others, such as the New York Power Authority, the Department of Transportation, and the New York State Energy Research and Development Authority, also participate actively in this process.

Given the policy guidance of the State Energy Plan, the Energy Authority reaches out broadly to ensure that its energy R&D plan is well informed. For example, we solicit a variety of points of view about how we should use our limited resources, what the R&D opportunities and needs are, and what R&D others are doing. We also solicit a review of the scientific and technical competence of our proposed program.

We plan at two levels. Overall, we develop a multi-year program plan. This plan establishes our programmatic goals and objectives, describes the rationale for why we have made the programmatic choices we have, and allocates resources for achieving them. At an operational level, our program directors and managers work with their staff members to develop detailed implementation plans for achieving our program plan goals and objectives.

This planning process and the resulting plans are used to communicate with a variety of state, national, and other public and private audiences. We use this process to guard against wasteful duplication and to identify possible collaborators and cosponsors. At its best, this process works as the initial step in putting together the consortia of sponsors and users needed to successfully achieve programmatic and project objectives. I have described this planning process to make the point that something comparable is needed at the national level.

As I observed in introducing this panel, our energy community is fragmented. Taking into account this fragmentation, how interrelated energy and other policy areas are—especially energy, the environment, and the economy—and the roles of the public and private sectors, it becomes clear that there needs to be a coordinated, collaborative energy R&D planning process. It is appropriate that this process be led by DOE; better yet, by DOE in conjunction with EPA and others.

We all need to remember the lessons of the late 1960s and the 1970s. That was a period of abundant, some would say lavish, funding for energy R&D. Most of you will probably agree that a lot of money was wasted, often because the Energy Research and Development Administration (ERDA), and later DOE program managers, sat in Washington and made the key technology R&D investment decisions. They didn't do the kind of reaching out that I am suggesting. Consequently, even if their programs were technically successful, the technologies themselves often sat on the shelf.

This leads me to a related point about technology transfer and commercialization. Tech transfer, commercialization, and similar buzz words seem to be everyone's pet topics these days—as they have been for years. The truth of the matter is that none of us know all that much about how to be consistently successful in seeing that the products of our research, development, and demonstration are widely applied.

Government is in a good position to be able to lead a planning process that results in identifying objectives. But government managers are not in a good position to decide which technologies the private sector will be willing to invest in.

In recognition of this, in implementing our R&D program, the Energy Authority (1) states the objectives we seek to achieve rather than promote a particular technology and (2) requires the beneficiaries of the program or project to make a significant investment in the project themselves. Both requirements are intended to increase the probability that results will actually be used.

I view the government's role as helping to make the risks associated with process changes and new technologies manageable. Only the people who will be making the changes can decide what process changes or new technologies they are willing to invest in. So the Energy Authority and DOE should let these people tell us what they are willing to invest in if we help make the risk manageable. And we should ensure that they are serious and not simply curious. We do this by making them have a high enough stake that they will actually use successful results.

DOE could help the states by adopting this approach and working with us on a programmatic basis in areas of mutual interest, e.g., energy efficiency in a variety of industries.

A final point about planning and DOE's role. In my opening remarks, I was going to say that there are no silver bullets. And I was going to quote Bill Clark [Secretary of the Interior in the Carter Administration] of the Kennedy School [John F. Kennedy School of Government, Harvard

University] in making the point that all our energy alternatives are vulnerable in one way or another.

Our energy future is at risk as a consequence of this across-the-board vulnerability. In fact, our level of risk is increased because of our lack of an adequate knowledge base for making well informed R&D and policy choices. We need a more comprehensive, comparative understanding of alternatives, including the energy, environmental, economic, social, and other implications of choosing from among them. DOE, in conjunction with other federal agencies, the states, and the private sector, should take the lead in developing this more comprehensive, comparative understanding.

DOE's Role

To this point, I have stressed the importance to the states of having DOE take the lead in developing a National Energy Strategy that articulates clear energy policy and R&D objectives. And I have made the point that it is essential that the process for developing these objectives and a plan for achieving them provide for the active participation of the states.

In the case of R&D, this active participation should include the New York State Energy Research and Development Authority and its equivalents in other states. DOE appears to be relying primarily on the National Association of State Energy Offices for state input in developing the National Energy Strategy. While this is appropriate for energy policy, I don't believe it provides an adequate input on energy R&D.

In my view, the role of state-level energy research organizations, such as the Energy Authority, is to do energy research, development, and demonstration to deal with state-level problems and to meet state-specific needs. In taking this approach at the Energy Authority, we try to find ways to apply new knowledge and technologies developed by others; and we adapt the results of national-level, generic research for application in New York State.

The Energy Authority is primarily in the business of knowledge application. However, when the DOEs, EPRIs (Electric Power Research Institute), GRIs (Gas Research Institute), DODs, DOTs (Department of Transportation), and others are not doing the generic, national-level research, development, and demonstration we need at the state-level, we step in to try to fill the gap.

Unfortunately, during the past decade we have had to step in more frequently than we would like. When we step in, we use an approach I strongly recommend to DOE. Employing this approach, the Energy Authority takes the lead in developing a public-private sector consortium of interested and affected parties to cosponsor the needed R&D. Public participation is interagency and intergovernmental, and private participation includes the industries and/or specific firms that will actually have to implement the results if the desired benefits are to be attained. These are the same firms that we depend on to play a major role in transferring knowledge and commercializing technologies.

Let me give you a quick example of how we used this approach in the solid management area. Solid waste management has clearly become a crisis for many local governments in the United States. As all of you know, historically most municipal solid waste has gone into landfills. But many of these landfills are now being closed. For a variety of reasons, it has become increasingly difficult to site new landfills. Moreover, other alternatives are not taking up the slack.

The underlying problems associated with solid waste management are not peculiar to any singular municipality or state. Rather, the problems are clearly national in scope.

Given the large direct energy potential associated with resource recovery and the substantial indirect energy potential associated with other alternatives for municipal solid waste, one should reasonably expect the federal government to take the lead in finding solutions. But it hasn't.

For purposes of my example, I will focus exclusively on the resource recovery/incineration alternative. When we became involved in the problem area of municipal solid waste several years ago, resource recovery/incineration was one of the most attractive management alternatives available to local governments. But it was being held hostage to a lack of knowledge about air emissions and ash residues. And municipal officials didn't have the knowledge base needed to answer the questions both they and their constituents had about the implications of deciding to build a resource recovery facility.

We were unable to get either DOE or EPA interested in taking the lead in conducting the R&D needed to provide a basis for municipal and state officials to make well informed decisions. Given the pressing nature of the problem in New York, especially downstate, New York had no choice but to take the lead.

Knowing how critical the credibility of results of any R&D on air emissions from a resource recovery facility would be, we went to the American Society of Mechanical Engineer's Committee on Dioxin to get that committee to develop and certify a combustion-testing protocol. We also established an advisory committee, the membership of which represented a variety of both points of view and relevant scientific expertise. And this committee was given an active role in designing and overseeing a key combustion-testing project.

Since the results would benefit everyone, not just New York State, we put together a finding consortium consisting of four other states, the federal and a provincial government of Canada, the national and international Vinyl Institute, and EPA. While they were not cofunders, we involved our State Energy Office, Public Service Commission, and State Department of Environmental Conservation as active participants.

The combustion and emissions data collected by this project, together with combustion and emissions data from several other incinerators, produced the only empirical data set available in this country, and I believe worldwide, on the relationship between the conditions of combustion and emissions. This data set is now being used extensively to raise the level of the debate about the air quality consequences of operating resource recovery facilities.

We have used the same consortia model on an even larger scale to deal with the ash residue portion of the problem. In this case, there are 21 cosponsors.

I can give you numerous other examples. But hopefully my point is clear; that is, that DOE and its sister federal agencies could benefit the states and the nation enormously by playing this kind of consortia-building role in a variety of generic, national-level problem areas. Federal agencies are in a much better position to do this than are we at the state level. And building these consortia in which the end users have a financial stake is much more likely to result in workable solutions that will actually be implemented than will any solution served up by federal program managers.

Some Other Suggested Areas for DOE Leadership

I know that GAO is particularly interested in energy efficiency, so I will concentrate on some specific things DOE might do to assist the states in this area.

Industrial Energy Efficiency. The industrial sector is a particularly promising target for improved energy efficiency. In fact, the Energy Authority gives industry a high priority in its Energy Efficiency and Economic Development Program area. And we have been quite successful. But overall, this is clearly a national rather than state-level activity; to be successful in realizing the energy savings potential will require a coordinated, collaborative national-level effort.

One thing that is conspicuous in this area is the lack of an equivalent to an EPRI or a GRI. I find this to be unfortunate in general and especially unfortunate with regard to energy efficiency. One or more industrial research programs comparable to EPRI/GRI could help U.S. industries to realize very large potential energy savings and help make U.S. industry more competitive.

To the extent we understand how most industrial and commercial managers make decisions, we find they are highly risk averse. Consequently, they are very reluctant to be the first to introduce either significant process changes or new technologies.

I have two specific suggestions for GAO and DOE for helping us get over this hurdle.

First, if process innovation and technology development were done collectively, individual firms might be less reluctant to introduce process changes and new technologies. So GAO and DOE should consider working with the Congress to promote the establishment of R&D consortia similar to the EPRI/GRI model, perhaps in several industrial sectors. (See P.L. 101-218, the Renewable Energy and Energy Efficiency Technology Competitiveness Act of 1989.)

Second, DOE should consider identifying selective industrial sectors in which it would take the lead in developing public-private sector consortia for promoting energy efficiency improvements.

The Energy Authority is prepared to work closely with DOE in this area, both in planning and implementation.

As a postscript, I should take note that we badly need to know much more about who actually makes process change and new technology decisions in industrial and commercial firms, and we need to know more about what the key criteria are that they use in making their decisions. It would be enormously helpful to have DOE take the lead in developing a higher level of understanding of what might be thought of as the sociology of various industrial sectors.

Lighting. Lighting is another high priority conservation/energy efficiency area in which DOE is a major player. For example, the work being done at DOE's Lawrence Berkeley Laboratory is first rate. But I recommend that DOE take an even more active role in lighting R&D.

I find lighting to be intriguing, in part because so many intelligent people have become advocates of a very simplistic approach, either forgetting or ignoring the close relationship between lighting and productivity. These people have become advocates without knowing the consequences of the lighting changes they propose on human performance and comfort. I believe it is clear and becoming even clearer that inadequately informed actions of this sort can actually lead to significant inefficiencies.

Recognizing that lighting represents a major area for decreasing energy consumption, the Energy Authority has participated actively for several years as a member of a national Ad Hoc Committee on Lighting. This committee, now chaired by a DOE deputy assistant secretary, includes among its members representatives of most of the interests at stake in lighting.

In discussions within this committee, it became clear at the outset that the interests of the members overlapped significantly. And we all agreed that more R&D was needed in lighting, especially research aimed at developing a better understanding of the relationship between lighting and human productivity factors and comfort. But, for a variety of reasons, committee members could not reach agreement on how to collaborate on the conduct of this research.

To shorten the story, the Energy Authority decided to force the issue by establishing a national lighting research center. We issued a competitive solicitation that provided for both institutional support and annual R&D funding for funding for 5 years. Before being issued, the request for proposal was widely reviewed by the lighting community, and I believe we had a high level of agreement on the approach we took.

On the basis of its response to the proposal, which was reviewed by a technical evaluation panel including several members of the Ad Hoc Committee on Lighting, the Rensselaer Polytechnic Institute was selected to be the site of the Lighting Research Center. The center, which just celebrated its second anniversary, has already established itself as a leading lighting research center not only nationally, but internationally.

I maintain that lighting R&D, especially R&D designed to provide better quality lighting at lower energy costs, is absolutely essential. We run a very high risk of contributing to inefficiency if we don't acquire a better understanding about the human performance factors associated with lighting. And the Rensselaer Lighting Research Center has developed and is continuing to develop the most comprehensive program in the world to acquire this understanding. We invite DOE, EPRI, EPA, other states, and others to join us in providing programmatic support to the Center.

Manufactured Housing. There is a critical need to advance the state of the art of housing construction technologies. The nation's home building industry is both large and widely dispersed. Largely because of its dispersed structure, for the most part, the industry neither supports nor conducts very much research. And the adoption of and adaptation to new energy efficient products and processes into construction practices are slow evolutionary processes. One consequence is that houses now being constructed are estimated to be 30 percent to 40 percent less energy efficient than economic state-of-the-art technology would support.

DOE has recognized this need by initiating and carrying out several programs, including establishing regional housing centers in Oregon and Florida. My understanding is that these centers conduct research and act as a source of information for builders in their regions. But research in these two regions does not meet the need in other regions. The Northeast is a prime energy efficiency target for another such center.

We have worked in this area for several years. Our current in-house funding for housing research and information dissemination is a little over $1.5 million. Our technology transfer activities include working with an advisory committee whose members include representatives of architectural educators, building design professionals, building contractors, trade unions, and officials responsible for building codes, among others. This committee provides guidance and oversight, including assisting in technology transfer and providing technical assistance to local builders in the use of innovative technologies and energy efficient building systems.

We would be delighted to collaborate and cooperate with DOE to broaden this program to cover the Northeast region. But even without such a center, we would welcome having DOE play a more active leadership role in the manufactured housing areas.

Other Energy Efficiency Targets. Other promising energy efficiency targets include the following:

- Heating, ventilating, and air conditioning (HVAC) equipment. Many companies that manufacture heating systems, air conditioners, and refrigeration systems are too small to conduct their own research. In addition, larger companies suffer from a "universal national product line" mentality, which doesn't adequately address regional differences and needs. Clearly there is a need for regionally differentiated, nationally coordinated HVAC research, development, and demonstration. And DOE would be the logical national leader.
- Energy Storage. There are a number of promising technologies, such as ice storage and aquifer thermal energy storage, that can save a great deal of energy. But commercial interest in these technologies is currently very limited. Batteries, as well as other possible means of electricity storage, remain an elusive but enormously important target of opportunity to improve the nation's use of electricity. And with the increased emphasis on renewable energy, storage becomes even more important.
- Industrial Processes. In addition to the examples I gave earlier, there are a large number of specific industries with pressing research needs. A few juicy targets that might be explored with industry are: reducing organic fumes from printing and other coating processes; promoting the safe use of waste solvents as fuels in cement and other high temperature kiln processes; lowering energy demands to condense milk and process cheese and other products; and promoting high technology drying of lumber, e.g., radiofrequency and heat pumps.

In all these examples, we at the state level would be delighted to have DOE take the lead. And the Energy Authority is prepared to collaborate and cooperate with DOE in developing programs and projects.

Electricity Supply

The power generation industry has undergone massive changes over the last 2 decades. It has gone from an era of steady, predictable growth to a decade of excess capacity to a present era of renewed, modest growth; competition with cogeneration developers to build new capacity; and a wide interest in issues like demand-side management. The new era is characterized by this certainty: once strong vendor research by major suppliers has greatly diminished. U.S. companies no longer dominate the utility market, as European and Japanese companies have maintained R&D and gained significant U.S. market access. Global climate and other environmental concerns have made the future of coal less certain. Gas is offered as the most desirable "bridging" fuel, but sizeable imports will be needed to support greatly expanded gas use. Imports are more costly and bring their own safety and balance-of-trade problems.

A very positive move recently has been better coordination between EPRI and DOE on electrical energy research. This is especially fortunate in view of the decreased activity of major U.S. vendors. In fact, one of the difficult decisions that we now face is whether our utilities should fund research by foreign firms if no American companies are interested. At any rate, it is imperative that coordinated, large-scale generation research be carried out somewhere to support the future improvement of our utility industry. There are several really difficult issues that the National Energy Strategy should address and attempt to resolve, notably the future of nuclear power and the role of coal. Whatever we decide to do, it is clear that we don't have the option of duplication and inefficiency. Future research has to be carefully coordinated and the expenses equitably shared.

The concept of demand-side management is of special interest to New York, which has committed itself to being in the vanguard of this issue. I am pleased that the Energy Authority has been able to work very cooperatively with DOE, the national labs at Oak Ridge and Berkeley, as well as the utilities on these issues. There is no reason why every state and every utility across the country has to duplicate the same program experiments in demand-side management. If we share our resources and experience, as we are in fact doing in this area, we will all find out much sooner which programs work and where the problems are. Electricity is so central to the well-being of a modern society that these issues deserve the most serious attention by DOE and the rest of us in a position to influence the future.

Alternative Vehicle Fuels

We applaud DOE for its leadership in the alternative vehicle fuels area. New York is working closely with DOE, DOT, EPA, and California in developing and implementing our own program.

This is another area where advocacy has outpaced knowledge. Our approach is to institute a rigorous monitoring and testing program to develop the knowledge base that New York State and New York City need to make well-informed policy choices. A description of our program is available if you are interested.

In addition to acknowledging DOE's assistance, my primary reason for mentioning the program is to call attention to the fact that alternative vehicle fuels, lighting, and any number of other areas of energy R&D do not fall exclusively within the jurisdiction of any single federal agency. GAO is in a position to help to ensure that federal programs in these areas involve all the agencies with jurisdiction and that the overall federal effort is both efficient and effective.

Summary

In my remarks, I have stressed the role of DOE as the nation's lead energy agency in planning and implementing a comprehensive energy R&D program designed to ensure the nation's energy future. I have made specific suggestions about both planning and implementation.

In all that I have said, I have stressed one underlying theme—that the energy policy and R&D enterprise is inherently jointly public and private and that on the public side it is both intra- and intergovernmental. Consequently, the only sensible approach is one based on cooperation and collaboration. And you should understand that cooperation and collaboration will work only if all the parties are participants in the creation.