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Report to the Chairman, Committee on Governmental Affairs, U.S. Senate

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ENERGY R&D

Conservation Planning and Management Should Be Strengthened

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Resources, Community, and
Economic Development Division

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The Honorable John Glenn
Chairman, Committee on Governmental
Affairs
United States Senate

Dear Mr. Chairman:

In response to your request and later discussions with your office, this report provides information on the Department of Energy's energy conservation research and development program and identifies planning and management improvements to increase its effectiveness. The report makes recommendations to the Secretary of Energy to improve the conservation program's multi-year planning process and to continue an independent peer review program that may be discontinued as an office-wide program because of the April 1990 reorganization of the Office of Conservation and Renewable Energy.

As agreed with your office, unless you publicly announce its contents earlier, we plan no further distribution of this report until 30 days from the date of this letter. At that time, we will send copies to interested parties and make copies available to others upon request.

This work was performed under the direction of Victor S. Rezendes, Director, Energy Issues. Major contributors to this report are listed in appendix III.

Sincerely yours,

J. Dexter Peach
Assistant Comptroller General

Executive Summary

Purpose

Energy efficiency technologies are recognized as a major factor in offsetting increased energy use related to economic growth. Reflecting support for public policy initiatives that foster alternative energy research and energy efficiency, the Chairman of the Senate Committee on Governmental Affairs requested a GAO study of federal energy conservation and research programs. As agreed with the Chairman's office, this report (1) provides an overview of the Department of Energy's (DOE) conservation research and development (R&D) program in terms of funding, government R&D policies, and technology successes and (2) identifies planning and management improvements to increase the effectiveness of the conservation R&D program.

Background

Increased energy efficiency can lessen our dependence on imported oil, reduce environmental problems associated with the use of fossil fuels, and enhance the competitive position of U.S. companies internationally. Following a decade in which conservation R&D program funding declined by more than 50 percent, the Secretary of Energy has said that energy conservation will be given increased priority in DOE. Increased priority for DOE's energy efficiency R&D program would support interim DOE National Energy Strategy (NES) report findings.[1] DOE's interim NES report said that broad public support exists for increasing energy efficiency and protecting the environment from the effects of energy production and use.

Results in Brief

In the 1970s and 1980s, the DOE conservation R&D program produced some commercially successful technologies, such as fluorescent lighting advances and low emissivity window coatings, that are providing energy savings and are expected to provide substantial savings in the future. In the early 1980s energy conservation R&D funding and staff were reduced substantially, reflecting the administration's view that conservation research should be conducted primarily by the private sector. Since the large cutback, funding has been relatively stable—it was $346 million in 1980, $152 million in 1982, and $149 million in 1990.[2] The 1991 budget request reflects a 9-percent program reduction compared with the prior year's appropriations.

[1]The NES is to be a "road map" for DOE's policy and funding initiatives. An interim NES report was issued in April 1990; the final report is to be presented to the President in December 1990.

[2]Amounts are expressed in 1982 constant dollars; years cited are fiscal years.

Since 1983, DOE's Office of Conservation has used a long-term planning process to produce an energy conservation multi-year R&D plan. However, the plan and the planning process could be strengthened to more fully meet the needs of policy makers. For example, the plan's usefulness and credibility would be improved if it provided detailed information on individual projects. Also, the planning process does not include systematic project reviews at DOE headquarters or use a uniform project prioritization methodology to rank projects. Systematic project reviews and a uniform prioritization methodology would (1) help ensure that ongoing research continues to be relevant and (2) provide information needed for DOE to select the best overall mix of conservation R&D projects.

Peer reviews, conducted under Conservation's "critical review" program, have enhanced DOE R&D management by providing independent, expert guidance to DOE on the continuing relevance of some of Conservation's programs to national and departmental objectives. The peer reviews have recommended changes to many of the programs that have improved them. However, the last peer review was completed in July 1988, and it is likely that the program will be discontinued as an office-wide program as a result of the April 1990 reorganization of the Office of Conservation and Renewable Energy.

Principal Findings

Conservation's R&D Funding Cuts and Technology Successes

During the 1980s, the administration supported federal long-term, high-risk basic research with a potential for high pay-off.[3] The philosophy was that the private sector could be relied on to support nearer term technology development. As a result, DOE's conservation applied R&D program sustained a 56-percent funding cut between 1980 and 1982. Since that time, in real terms, funding has remained at about 50 percent or less of 1980 funding. Although the Secretary of Energy said the Department will give increased priority to DOE's Conservation program, the fiscal year 1991 budget request would reduce Conservation's R&D funding by about 9 percent compared with 1990 appropriations.

[3]Basic research is directed at discovering fundamental new knowledge, whereas applied research is the use of new knowledge to meet recognized needs.

In the past 2 decades, Conservation's R&D successes include advances in fluorescent lights, windows, and industrial processes. Two DOE Conservation-supported technologies in materials were cited among the 20 key technology developments of the 1980s in a periodical, High Technology Business.

The Multi-Year Plan

The Office of Conservation's long-term planning process has established broad research priorities that are presented in each year's Energy Conservation Multi-Year Plan. However, the plan is not as useful to executive branch and congressional decision makers as it could be because it does not provide detailed information on the proposed individual projects and milestones. This information would increase both the credibility of the plan and its usefulness as a management tool to enhance accountability.

The multi-year planning process could be improved in a number of ways. For example, the planning process is not based on a systematic review of individual projects by top management. Such a review is needed to ensure that the DOE conservation R&D portfolio reflects current needs and priorities and that outdated and/or weaker projects are terminated expeditiously. In addition, in the planning process, each of the four conservation R&D program offices used its own prioritization methodology and DOE has therefore been unable to compare the costs and benefits of its proposed energy conservation R&D activities. Specifically, two offices used a nonquantitative, judgmental approach and two have used quantitative analyses on the basis of different measures—one used a cost/benefit measure and the other a benefits measure.

The Critical Review Program

The DOE conservation critical review program has been successful in providing DOE with guidance from independent, outside experts on the relevance of its research efforts. Numerous projects have been identified as candidates for termination or reorientation, and DOE has made some changes on the basis of the recommendations. However, formal monitoring of DOE responses is not done at DOE headquarters, and documentation and communication of DOE responses to peer review recommendations is limited. For these reasons, DOE may inadvertently overlook some relevant recommendations or fail to implement them in a timely manner.

The last peer review was completed in July 1988. Uncertainties surrounding the reorganization of the Office of Conservation delayed

planned reviews. Further, the continuation of the critical review program as an office-wide program is questionable because the reorganization places each of the conservation program offices under its own deputy assistant secretary, rather than under the one deputy assistant secretary who established the program. The Assistant Secretary said that although the deputy assistant secretaries must follow broad management guidelines, he will rely on each of them to determine how their program will be reviewed.

Recommendations

To enhance the usefulness and credibility of the conservation R&D multi-year plan, we recommend that the Secretary of Energy require detailed program and project information in the plan, including objectives and milestones.

We also recommend that the Secretary of Energy require that the conservation R&D planning process (1) include a systematic review of individual projects by top Office of Conservation management to help ensure that the portfolio reflects current needs and (2) use a uniform project prioritization methodology to compare the costs and benefits of its proposed activities.

To ensure that conservation R&D programs continue to receive independent reviews under the revised organizational structure of the Office of Conservation and Renewable Energy, we recommend that the Secretary of Energy require the cognizant deputy assistant secretaries to implement independent peer reviews annually and examine peer review recommendations as part of the Office's multi-year R&D planning process.

The report also contains other recommendations regarding Conservation's multi-year planning process.

Agency Comments

As requested, GAO did not obtain official agency comments on a draft of this report. However, GAO did meet with agency officials, who agreed with the facts. GAO has also included their comments where appropriate.

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Abbreviations

AHX	Advanced Heat Exchanger
DOE	Department of Energy
ECUT	Energy Conservation and Utilization Technologies
GAO	General Accounting Office
GRI	Gas Research Institute
NES	National Energy Strategy
OMB	Office of Management and Budget
R&D	research and development

Introduction

Energy conservation, the more efficient use of energy, can increase national energy security and environmental quality as well as the economic competitiveness of U.S. companies in international markets. Energy efficiency technologies are also recognized as a major factor in offsetting increased energy use related to increased economic activity. For example, according to the Department of Energy (DOE), while the economy grew by 46 percent since 1973, U.S. energy use grew by only 7 percent because of energy efficiency gains.[1]

DOE's energy conservation research and development (R&D) program has contributed to the technology base that has brought about energy efficiency improvements. However, funding for the program declined significantly in the past decade despite some low-cost successes.

As requested by the Chairman of the Senate Committee on Governmental Affairs, our report provides a historical perspective of the program over the last decade and examines DOE's energy conservation R&D planning and management processes. This chapter discusses the benefits of energy efficiency, some DOE efficiency technology successes, the conservation program's funding history from 1980 to 1990, and the R&D policies governing the program during this period. Chapter 2 addresses planning changes that will improve the usefulness of the energy conservation multi-year R&D plan. Chapter 3 examines DOE's use of an independent peer review process, called the "critical review program," to oversee its energy conservation R&D program.

Energy-Efficiency Technologies Provide Multiple Benefits

Energy efficiency is responsive to three national concerns. First, energy efficiency enhances energy security by reducing energy needs, thereby providing protection against growing U.S. dependence on imported oil and the possibility of inadequate electricity supplies in this decade. Second, energy efficiency can provide important environmental benefits. For example, energy production and use are responsible for nearly 60 percent of society's contribution to enhanced global warming, also referred to as the "greenhouse effect."[2] Carbon dioxide, a suspected cause of the greenhouse effect, is a by-product of burning fossil fuels such as coal and oil. Increased energy efficiency can reduce greenhouse

[1]Energy Conservation Trends, Understanding the Factors That Affect Conservation Gains in the U.S. Economy, U.S. Department of Energy, Sept. 1989.

[2]Mounting evidence indicates that pollution from the release of carbon dioxide and other gases into the atmosphere may be producing a long-term and substantial increase in the earth's average temperature.

gas emissions by slowing the rate of fossil fuel use and provide additional time to develop energy supply options. Third, improved energy efficiency can improve U.S. competitiveness by reducing production costs, by increasing productivity, and by adding new technologies that become U.S. products for domestic and foreign markets.

DOE's Conservation R&D Program Has Produced Energy Efficiency Technologies

In the last 2 decades, the conservation R&D program has produced some commercially successful technologies that are providing energy savings now and are expected to provide substantial savings in the years ahead. DOE reports of successful energy efficiency technology transfer[3] include advances in fluorescent lighting, windows, heat pumps, and industrial processes, among others. A number of the successes were achieved with minimal federal investment. For example, according to DOE, a fluorescent lighting technology, which has potential energy cost saving benefits of $3.3 billion by the year 2010, cost DOE just $0.6 million. Furthermore, two DOE conservation technologies in materials were recently cited among the 20 key technology developments of the 1980s in a periodical, High Technology Business. Additional information on some of these energy efficiency technology successes is provided in appendix I.

Conservation R&D Research Topics

Fiscal year 1989 funding of $165.7 million (in actual dollars) supported about 475 research projects conducted under the auspices of four energy conservation R&D program offices—buildings, transportation, industry, and energy utilization research. The broad spectrum of the research topics conducted in 1989 is reflected by the following list of representative research topics:

- Office of Buildings and Community Systems. Buildings materials, windows and daylighting, indoor air quality, building performance simulations, existing building retrofits, heat pumps, advanced refrigeration systems, lighting equipment.
- Office of Transportation Systems. Gas turbine vehicle propulsion, advanced materials development, materials design methodology, alternative fuels utilization, synthetic fuels, electric and hybrid propulsion testing and evaluation.

[3]Technology transfer is the transformation of R&D into processes, products, and services that can be applied to private sector and government needs.

- Office of Industrial Programs. Waste heat recovery (advanced heat exchangers and industrial heat pumps), combustion efficiency improvements, waste products utilization, industrial process efficiency, sensors and controls, industrial cogeneration.
- Office of Energy Utilization Research. Engine combustion, superconducting materials, high-temperature materials, corrosion resistant materials, applied microbiology and genetics, advanced lubrication research.

According to the Special Assistant to the Deputy Assistant Secretary for Conservation, DOE's conservation R&D activities are predominately, if not all, applied research in nature.[4]

Management Structure Changed in Recent Office Reorganization

On April 18, 1990, DOE's Assistant Secretary for Conservation and Renewable Energy announced an office reorganization that ended the separation between the conservation and renewable energy research programs. The four conservation and the four renewable energy R&D program offices that had been managerially and programmatically separate were merged into four new offices, each headed by a deputy assistant secretary who reports to the Assistant Secretary through the Principal Deputy Assistant Secretary.[5]

The new, consolidated R&D program offices of industrial, transportation, building, and utility technologies organize all conservation and renewable R&D in terms of end-use sectors of the economy. The reorganization continues the end-use orientation already used in Conservation's industrial, transportation, and buildings program offices and merges with them the relevant renewable R&D. For example, biofuels R&D formerly conducted in a renewable energy program office will now be conducted in the consolidated conservation and renewable energy transportation office. Conservation's energy utilization activities—cross-cutting research that can be adopted by the end-use programs and the private sector for their specific applications—is now included within the relevant end-use program offices, primarily industrial and transportation. The largest portion of the renewable energy R&D formerly conducted in four program offices will now be conducted in the new utility office.

[4]Applied research is the use of new knowledge to meet recognized needs, whereas basic research is directed at discovering fundamental new knowledge.

[5]Before the reorganization, the conservation program offices reported to the Deputy Assistant Secretary for Conservation and the renewable energy program offices to the Deputy Assistant Secretary for Renewable Energy.

During our review, the conservation program offices operated separately, each using its own planning and management processes, under the guidance of the Deputy Assistant Secretary for Conservation. While the reorganization creates an Office of Planning and Assessment, this office will only consist of four or five individuals who will provide planning guidance, coordination, and oversight. The R&D planning will continue to be done by each R&D program office. The Assistant Secretary said that each deputy assistant secretary will determine the specifics of how research is conducted and reviewed, following broad management guidance from him.

Conservation programs use a decentralized management structure with DOE headquarters, DOE operations offices (field offices), DOE laboratories, and other outside entities, such as the National Air and Space Administration's Lewis Research Center, providing planning and management services. Conservation R&D is conducted by DOE and other government laboratories and contractors who often provide cost sharing. In 1989 laboratory use varied considerably between the four programs, ranging from about 30 percent to 75 percent, with contractors and universities conducting the balance of the research.

DOE's Conservation R&D Program Has Sustained Funding Cuts and Policy Changes

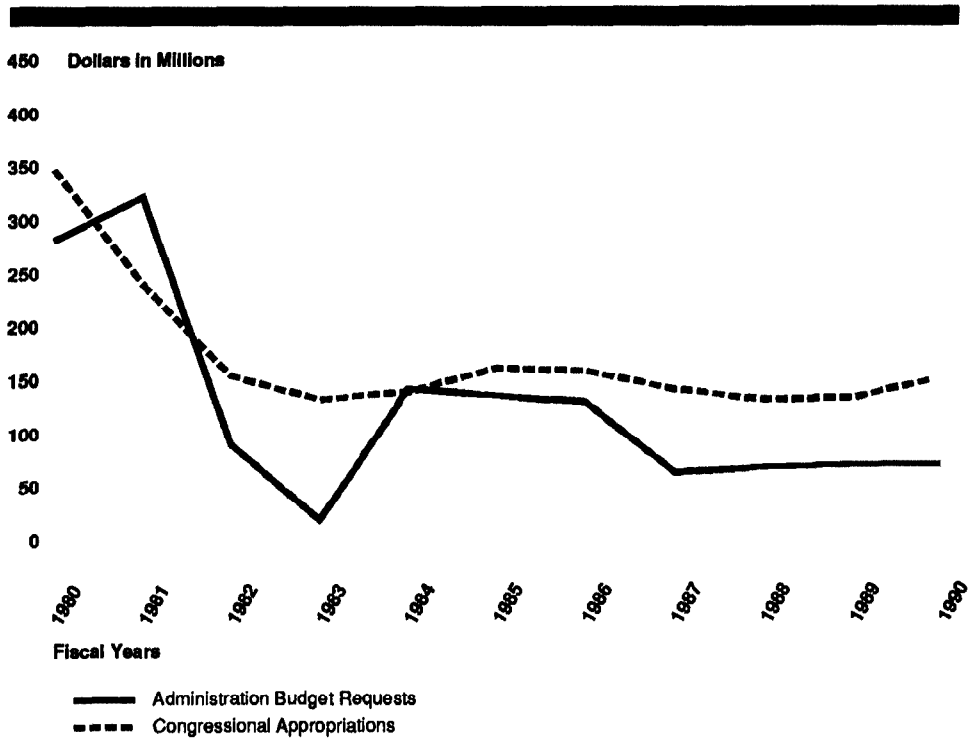
Predominately an applied research program, the DOE conservation R&D program that existed in the 1970s was not consistent with the administration's R&D policy in the 1980s, which focused on long-term, high-risk research with a potential for high payoff. The administration proposed redirecting nonnuclear R&D programs, such as conservation, toward longer term, generic research. The philosophy was that the private sector could be relied on increasingly to support nearer term technology development. As a result, DOE's conservation R&D program was reduced substantially in the early 1980s.

From 1980 to 1982, DOE's conservation R&D funding was cut 56 percent, from $346 million to $152 million[6] (see fig. 1.1). Since 1982, in real terms, funding has remained at about 50 percent or less than funding in 1980, even though the Congress has generally appropriated about twice the amounts requested by the administration in recent years.

From 1980 to 1982, when program funding was reduced substantially, DOE headquarters conservation R&D staffing dropped from 208 to 114. In

[6]Amounts are expressed in 1982 constant dollars; years cited are fiscal years.

Figure 1.1: DOE Conservation R&D Budget Requests and Appropriations, 1980-90



Source: DOE Office of Conservation, adjusted to 1982 constant dollars. The 1982 budget request reflects the Reagan Administration's amendment to the $306 million Carter budget request.

1989 the staffing level was at 137. According to Conservation data collected from DOE laboratories and operations offices, 29 laboratory and operations office staff also conducted conservation R&D planning and management activities in 1989.[7]

In a statement accompanying the fiscal year 1991 budget, the Secretary of Energy said that energy conservation will be accorded increased priority in DOE. The statement supports targeted federal efforts to bring energy efficiency technologies into private sector use. In addition, short-, mid-, and long-term applied research efforts in the conservation R&D program are to be articulated. While the 1991 request is twice as large as the 1990 budget request, it would reduce DOE's conservation R&D funding by 9 percent compared with 1990 appropriations.

The fiscal year 1991 request reflects numerous program changes, such as

[7]Staffing is expressed in full-time equivalents; years cited are fiscal years.

- a 27-percent increase in the buildings program that includes a doubling of funding for technology assessment and transfer;
- a 22-percent decrease in the industrial program, primarily reducing the process efficiency research;
- a 14-percent decrease in the transportation program that includes large funding cuts for the electric vehicle program and increases for the alternative fuels program; and
- an 11-percent decrease in the energy conversion utilization program, primarily in activities relating to materials R&D.

According to the Assistant Secretary for Conservation and Renewable Energy, the fiscal year 1991 budget request reflects a conservation R&D program that will be better focused and better managed, and include increased levels of private-sector cost sharing. For example, he said that the number of electric vehicle batteries being researched will be reduced to conduct a more focused and effective effort.

The Secretary's budget statement indicated that the fiscal year 1991 request considered, to some extent, public input received during the National Energy Strategy (NES) development process and that the 1992 budget would be more closely linked with the final NES.[8] DOE's interim NES reported broad public support for increasing energy efficiency and protecting the environment from the effects of energy production and use. As discussed earlier, one of the benefits of energy efficiency technologies is the enhancement of environmental quality.

Objectives, Scope, and Methodology

The Chairman of the Senate Committee on Governmental Affairs requested a GAO study of federal energy conservation and research programs. As agreed with the Chairman's office, our review had two primary objectives:

- To provide a historical view of DOE's energy conservation R&D program in terms of funding, government policies, and program achievements.
- To identify planning and management improvements that could increase the effectiveness of DOE's energy conservation R&D program.

To provide the historical context for the program, we obtained the program's funding and staffing history for the period from fiscal year 1980

[8]The NES is to be a "road map" for DOE's policy and funding initiatives. An interim report, based on public hearings and written statements and reports, was issued for public comment in April 1990. The final NES is to be presented to the President in December 1990.

through 1990 from DOE Conservation officials and examined the related policy statements contained in the President's budget documents up through the fiscal year 1991 budget. We obtained information on the commercialization of some DOE-supported energy-efficiency technologies. However, we did not attempt to carry out a systematic assessment of DOE's success in commercializing its energy conservation research efforts, nor has DOE conducted such an assessment.

To address the planning and management issues, we reviewed DOE's Energy Conservation Multi-Year Plans issued from 1985 through 1988, as well as the draft plan prepared in 1989. We met with DOE officials in the Office of the Deputy Assistant Secretary for Conservation and the four program offices to obtain information on the planning processes, project prioritization methodologies, and the documents supporting the plans. We analyzed the National Research Council's 1986 report, Planning for Energy Conservation R&D: A Review of the DOE's Planning Process, and considered DOE's responses to it.[9] The Council found Conservation's planning process to be sound but made numerous recommendations for improving it, a number of which have not been implemented.

We also analyzed 12 independent critiques of DOE energy conservation R&D programs conducted between 1985 and 1988 by representatives primarily from industry and academia. Ten of the reviews were conducted under the auspices of a critical review program established by the Deputy Assistant Secretary in 1985.[10] The other two independent reviews we examined, conducted by the National Research Council, were brought to our attention by the program offices. The independent review coverage includes programs and projects in each of the four Conservation offices. We did not include the Inventions and Innovation Program, part of the Office of Energy Utilization Research, in the scope of our work because it does not plan and manage energy conservation R&D; rather, it funds inventions of individual inventors, small businesses, and research groups.

We conducted four case studies of the following programs that had undergone critical reviews to obtain an understanding of DOE's responsiveness to the recommendations and suggestions made in the related critical review reports:

[9]The Council is the principal operating agency of the National Academy of Sciences and the National Academy of Engineering.

[10]No critical reviews were conducted on conservation R&D programs in 1989.

- Electric Vehicle Propulsion System R&D Program, Office of Transportation Systems.
- Aluminum Research Program, Office of Industrial Programs.
- Building Materials Program, Office of Buildings and Community Systems.
- Energy Conversion and Utilization Technologies Materials Program, Office of Energy Conversion and Utilization.

The case study coverage includes (1) one program in each of the four program offices and (2) work managed and/or conducted by staffs at DOE headquarters, three DOE operations offices (Oak Ridge, Tennessee; Richland, Washington; and Idaho Falls, Idaho), and three DOE laboratories (Oak Ridge National Laboratory, Pacific Northwest Laboratory, and the Idaho National Engineering Laboratory).

In developing our planning and management recommendations, we compared DOE's planning process with that of the Gas Research Institute (GRI). GRI is a nonprofit research management organization that plans and manages predominately applied energy R&D activities to benefit the natural gas industry and its customers. GRI's annual funding, $175 million for 1989, closely approximates that of DOE's. Formed in 1976, GRI collects funds through its industry members, and its program is reviewed and approved annually by DOE's Federal Energy Regulatory Commission. GRI, which sponsored over 200 research projects in 1989, uses a centralized management structure. Its planning and management processes have been endorsed by the National Research Council as being effective and competent.

Our work was conducted from April 1989 to March 1990 in accordance with generally accepted government auditing standards. We discussed the contents of this report with responsible DOE officials, who agreed with the factual information; we have incorporated their comments where appropriate. As requested, we did not obtain formal agency comments.

DOE's Conservation R&D Multi-Year Planning Process Should Be Improved

Long-term R&D plans should provide executive branch and congressional policy makers with guidance that is useful for making funding decisions. The long-term planning process used by DOE's Office of Conservation to produce its R&D "multi-year plan" has met some of the information needs of federal decision makers, such as identifying and prioritizing research topics for each of the four program offices. The plan's usefulness for planning and management purposes, however, is hampered because it does not provide detailed information on individual projects and because its planning process does not (1) include a systematic review of ongoing individual projects, (2) use a uniform project prioritization methodology, (3) provide for systematic consideration of project technology transfer requirements, or (4) develop program plans using varying funding levels. The GRI's multi-year R&D plan is a model that could be adapted by DOE to improve its multi-year plan and planning process.

Long-Term Planning Is Important

In a 1984 report on DOE planning for energy R&D,[1] we discussed some of the potential benefits of effective long-term planning, such as (1) providing congressional and executive branch decision makers with needed details on the anticipated results and potential impact of funding for future energy technologies and (2) maintaining support for ongoing projects to achieve the desired results.

Effective planning processes can also provide greater assurance that work that is no longer promising and/or pertinent to current national needs is terminated expeditiously. To the extent that weak projects are not weeded out in a timely manner, new projects may be delayed or omitted. This is particularly important to conservation programs because DOE's conservation R&D funding has not kept pace with inflation in recent years.

Conservation's Multi-Year R&D Plan

To its credit, from 1983 to 1989, DOE's Office of Conservation used a long-term planning process covering 5-year periods to produce an energy conservation multi-year plan.[2] The plan's stated purpose is to describe program activities and realign program emphases, if necessary,

[1] A Long-Term Plan Is Needed to Guide DOE and Multi-Program Laboratory Research and Development Activities (GAO/RCED-84-30, Jan. 16, 1984).

[2] The August 1989 plan for fiscal years 1991-95 was not published and distributed because of Office concerns that some analyses would conflict with more sophisticated analyses being developed for the National Energy Strategy.

in light of changing energy and technological conditions. DOE's August 1988 multi-year plan provided information on each of the four conservation R&D program offices, such as:

- Program office mission, objectives, and strategies.
- Potential program benefits primarily expressed in terms of possible energy savings.
- A prioritized list of about 25 to 40 "project" candidates for federal support for the 5-year period covered, including proposed new initiatives. (Multi-year plan "projects" are typically groupings of related projects (project areas). Each office's 25 to 40 project areas represents more than 100 individual projects.)

The plan also contained background information such as policy goals; the energy supply and demand outlook, and the Office of Conservation's organization, mission, objectives, and technology transfer strategy.

The plan has provided federal policy makers with some important information needed to make informed R&D funding decisions. For example, decision makers can use the prioritized research recommendations provided for each program office to determine which research areas to support in the four program offices. The plan has also served as a vehicle for program offices to identify and recommend new research initiatives, an important planning activity. In addition, the plan has been a communication vehicle for the conservation R&D programs. Distributed to other DOE offices, DOE laboratories, outside research and energy organizations, and congressional committees, the plans have generated feedback on the program priorities and planning methodologies they contain.

For the 1992-96 planning period, the Office is conducting an abbreviated multi-year planning exercise. According to the Principal Deputy Assistant Secretary for Conservation and Renewable Energy, changes include (1) basing the plan implicitly on the draft National Energy Strategy and not presenting the national policy context for the R&D program and (2) not publishing and distributing the plan externally at least for several years while the Office revises and refines some of its planning methodologies.

The Multi-Year Plan and Planning Process Have Shortcomings

While DOE's conservation R&D multi-year plan provides some benefits, it does not fully serve the needs of policy makers because it does not provide information on individual projects being proposed and its planning process does not

- include a systematic review of ongoing research to provide assurance that the highest priority work is being conducted and that outdated or lower priority activities are terminated expeditiously;
- prioritize all research activities using a uniform methodology to permit an evaluation of the relative merits, such as costs and benefits, of the research priorities across the four program offices;
- provide for systematic review of technology transfer needs to provide assurance that technology transfer receives appropriate attention; or
- develop plans at varying funding levels to efficiently support the budgeting process.

The need for (1) a systematic, documented review of ongoing research, (2) a uniform prioritization methodology, and (3) technology transfer improvements were also identified in the 1986 National Research Council report on DOE's energy conservation planning process.

Information on Individual Projects Is Not Provided

DOE's conservation multi-year plan does not provide the objectives, costs, and milestones for the individual projects included in its recommended technology areas, nor does it identify all of the individual projects being proposed. Instead, the recommended project areas are described in broad terms. The justifications for multi-million-dollar, multi-year R&D investments are provided in a few sentences that typically identify some, but not all, of the research activities being proposed.

According to the Deputy Assistant Secretary for Conservation, the level of detail provided in the multi-year plan is appropriate, given the numerous projects included in the portfolio and considering report volume constraints. He said that rather than developing project details in the planning process that precedes the budgeting cycle, Conservation's practice is to develop them in "annual operating plans" following the passage of appropriations, that is, once actual funding for the year is known.

Still, the broad descriptions used to discuss ongoing and planned projects in the multi-year plan reduce its usefulness and credibility because they do not inform decision makers about

- the current and projected status of the research;
- the individual projects being proposed, along with their related costs, objectives, and milestones;
- accomplishments to date, technology transfer plans, and internal and external coordination activities;
- changes in response to internal and external reviews or technology assessments;
- any co-funding by industrial participants; or
- the interrelationships between the projects, e.g., what support elements are critical to achieving program goals.

Furthermore, the annual operating plans that are prepared following the appropriations process vary between the four program offices in terms of the project detail provided.

Individual Projects Are Not Systematically Analyzed

DOE's multi-year planning process does not include systematic internal reviews of on-going conservation R&D activities. Such reviews would provide greater assurance to federal decision makers that the portfolio includes those research efforts that best meet national and program needs. Systematic project reviews are not conducted at DOE headquarters despite a National Research Council recommendation in 1986 that, to increase management effectiveness, DOE's conservation planning process should include a systematic analysis of projects with explicit criteria showing reasons for project continuations or terminations. This National Research Council recommendation echoes industrial R&D principles that planning should start with a critical assessment of the current projects being conducted and that this assessment supplement periodic budget monitoring and progress reviews.[3]

Factors specific to the conservation program further underscore the need for high-level headquarters oversight of conservation projects, particularly to ensure that projects are terminated or redirected as necessary. Specifically, deficiencies in Conservation's planning guidance—statements of goals, objectives, and strategies—may result in project termination problems. This concern was cited in the 1986 National Research Council report on Conservation's planning process. The Council noted that it is difficult to terminate projects because criteria for judging accomplishments are incorrect or inadequate or because

[3]Anthony J. Gambino and Morris Gartenberg, Industrial R&D Management (New York: National Association of Accountants).

objectives are unrealistic. The Council also said that project decision milestones should be presented over the 5-year planning horizon.[4]

Similar concerns regarding the adequacy of objectives and milestones were raised in a number of the independent program reviews we examined. Specifically, 6 of the 10 independent peer reviews of conservation programs conducted under Conservation's critical review program (see ch. 3) identified weaknesses with Conservation's objectives and milestones. In addition, the independent reviews included a number of recommendations on project terminations and redirections. Furthermore, the Deputy Assistant Secretary acknowledged that the multi-year planning process does not provide a mechanism for weeding out weaker projects because it examines project areas, not individual projects.

In spite of these concerns, the Deputy Assistant Secretary did not believe that individual project reviews were needed in the multi-year planning process because (1) project reviews occur throughout the year in program reviews conducted within the four program offices and (2) the critical review program he initiated in late 1985 complies with the National Research Council's recommendation for documented annual project reviews. Because of these reviews, he believed the risk of inappropriately continuing research is minimal.

While we recognize that DOE does conduct program and project reviews throughout the year, we do not believe they provide the systematic, high-level oversight needed to manage DOE's conservation research portfolio. The Deputy Assistant Secretary for Conservation confirmed that reviews of individual projects generally are not conducted or reviewed by management above the program office level. Therefore, periodic conservation program and project reviews are not used to support a systematic assessment of all on-going research by top management as a foundation for planning and budgeting decisions, such as portfolio priorities.

The critical review program cited by the Deputy Assistant Secretary does provide for the independent review of selected research programs. However, under this program (1) only a few program reviews are conducted each year and (2) the reports vary in the degree of specificity

[4]Substantive planning changes, such as revising objectives and including multi-year project milestones, were not implemented because the Deputy Assistant Secretary did not believe changes in the nature of the plan and the effort leading to it were warranted.

relating to individual projects. As such, we do not believe this program provides compliance with the Council's recommendation.

A Uniform Project Prioritization Methodology Is Not Used

Reflecting the autonomy in planning and management that has been afforded the four conservation R&D offices, each office has developed its own prioritization methodology for use in the multi-year planning process. Therefore, DOE is unable to compare the costs and benefits of its proposed R&D activities.[5] For example, two offices have used nonquantitative, judgmental approaches to develop their project area priorities in recent plans. The other two offices have conducted a quantitative analysis of their project areas that was judgmentally adjusted. However, the quantitative analyses were not conducted on the same basis. That is, one office used a benefits analysis and the other a cost-benefits analysis to develop its initial prioritized project area listings. Because they are based on differing methodologies, the four offices' prioritized project lists in the multi-year plan cannot be used to support rational program selections among the program offices and consequently do not enhance decision-making aimed at achieving the best overall mix of conservation R&D projects.

According to industrial R&D principles, the ideal portfolio selection approach involves a combination of a quantitative method and professional judgment. Also favoring a quantitative base and professional judgment for portfolio selection, the National Research Council said in its 1986 report on DOE's conservation R&D planning that an appropriately designed quantitative methodology can enhance the quality of planning decisions, increase the level of confidence in decision-making, and help to communicate this confidence to higher level decision makers. Finding the conservation R&D offices' planning methodologies to be based extensively on the professional experience and intuition of the program managers, the Council said that the Office of Conservation should study more formal methodologies.

According to the Deputy Assistant Secretary and his Special Assistant with R&D planning responsibilities, the Council's 1986 recommendation regarding planning methodologies was not pursued by the Office because the Deputy Assistant Secretary for Conservation decided not to change the nature of the plan and the effort leading to it. They also

[5]This is also a DOE-wide problem that is discussed in our report, Energy R&D: DOE's Allocation of Funds for Basic and Applied Research and Development (GAO/RCED-90-148BR, May 24, 1990).

expressed skepticism over the feasibility and cost of developing an adequate, uniform measure that would be appropriate for its diverse programs. Along these lines, in his December 1986 memorandum to the Assistant Secretary briefly summarizing Conservation's response to the Council's report, the Deputy concluded that additional resources for planning were not appropriate, given tight budgets and energy prices and supply availability. In February 1990, however, the Principal Deputy Assistant Secretary for Conservation and Renewable Energy said that he and the new Assistant Secretary are strongly in favor of developing a uniform prioritization methodology for use in all office programs, for both conservation and renewable energy R&D.

Technology Transfer Planning Needs Improvement

Independent reviews of DOE conservation R&D programs show that technology transfer activities that effectively promote the commercialization of research efforts were performed unevenly. For example, while most of the 10 critical reviews we examined contained some positive comments regarding technology transfer activities, all of the reviews identified technology transfer weaknesses. The most common problem cited was not sufficiently identifying user needs. Failure to adequately define user needs is significant because the ultimate goal of Conservation's applied research efforts is the application of the resulting technologies, processes, or information by private and public sector users—technology transfer. When research projects are technically successful but fail to result in commercialization, national energy efficiency is not improved nor do taxpayers receive a return on their investment.

Reflecting the contribution that systematic planning can make toward achieving technology transfer, the National Research Council's 1986 report on DOE's conservation R&D planning said that decisions related to project initiation, continuation, and phaseout should explicitly reflect criteria related to technology transfer possibilities and strategies. A systematic review of technology transfer activities would logically be incorporated into the systematic, individual project review process also proposed by the Council, discussed above, that DOE has not implemented.

The 1986 National Research Council report also recommended that each Conservation program office develop and describe its technology transfer strategy and that these strategies be articulated in the multi-year plan. According to the Council, DOE should evaluate technology transfer requirements and potential of projects at their inception by

- taking technology transfer requirements into consideration in setting program priorities and
- seeking to involve the private sector in the planning process through committees, symposia, and other interactive mechanisms.

In the past 2 years, the Office of Conservation has formalized its technology transfer strategies.[6] In addition, the August 1988 multi-year plan briefly outlined Conservation's approach to technology transfer. The strategies cited include those elements specifically mentioned by the National Research Council, such as seeking early involvement with the private sector. The development of the strategies is an important first step in improving technology transfer of conservation R&D. However, as discussed above, DOE has not taken action to ensure consistent implementation of the strategies by conducting systematic, individual project reviews that include an examination of technology transfer strategies.

Budget Formulation Needs Are Not Met

DOE's conservation planning process is not linked with DOE's budgeting requirements. Specifically, the multi-year planning process produces project area funding estimates at one level rather than at varying levels as is required in budget formulation.[7] According to the Deputy Assistant Secretary, the technical assessment of research needs and program priorities in the planning process assumes the availability of unlimited funding and represents the outside bounds of possible research. For example, the last published plan, Energy Conservation Multi-Year Plan 1990-1994, dated August 1988, included $254 million for conservation R&D for fiscal year 1990, whereas the administration's budget request for 1990 was $88 million and the Congress appropriated $193 million. Furthermore, the planning process does not relate proposed funding amounts to projected completion dates or other major milestones for the specific research projects to be conducted, reducing its usefulness to decision makers.

DOE conservation managers said that the decision to keep the planning and budgeting activities entirely separate was based on concerns that

[6]Technology Transfer Strategies of the U.S. Department of Energy's Conservation Program, Dec. 1988.

[7]Within DOE's budget process, Conservation develops three budgets on the basis of the following assumptions: the Office of Management and Budget (OMB) target, the OMB target minus 10 or 15 percent, and program plans in excess of the OMB target.

the Office of Management and Budget (OMB) would not allow Conservation to develop a plan that could be viewed as an alternative to the President's budget. To place this planning effort in context, the multi-year plan was initiated when administration budget requests included substantial conservation R&D program cuts. Conservation did not want to restrict the thinking of the program offices by establishing funding limits in the planning process. Consequently, the plan is specifically devoid of budget guidance. For example, it is not linked to OMB targets or to congressional authorizations for conservation R&D that are provided for 3-year periods.

One way in which the plan could better meet budgeting needs would be to examine multiple funding levels for the conservation R&D program. For example, the process could incorporate at least one funding target that would permit program growth. The use of multiple funding levels during planning would efficiently support the budgeting process in which varying funding amounts are examined and incremental funding decisions are made.

GRI's Process Offers a Model to Improve DOE's Plan and Planning Process

The Gas Research Institute's energy R&D planning process is a model that DOE can use to address each of the shortcomings discussed above. In its 1989 report, A Review of the Management of the Gas Research Institute, the National Research Council concluded that GRI's planning system was disciplined, quantitative, and systematic and that its program implementation was competent and effective. The Council also said that GRI has a well-thought-out approach to commercialization and to technology transfer, and its record shows that its approach is generally effective.

The GRI planning and management techniques that could improve DOE's shortcomings with respect to individual project information, project reviews, funding estimates, prioritization methodologies, and technology transfer planning are summarized below.

- The GRI plan succinctly identifies the individual projects being proposed, and provides other important information such as project objectives, costs, multi-year milestones, and accomplishments.
- GRI uses a senior management committee to systematically review project-level-and-above budgets, strategic emphasis, program direction, and R&D progress and goals.
- GRI uses a uniform, quantitatively based system for prioritizing its diverse project areas.

- GRI's technology transfer strategy and plans are systematically considered and emphasized by GRI's use of uniform milestones and decision points that specifically highlight technology transfer activities.
- The GRI R&D plan is formulated after consideration of four funding levels for each project area.

Additional information on these GRI techniques is provided in appendix II.

Conclusions

DOE's conservation multi-year R&D plan does not provide detailed information on the proposed individual projects and milestones. This information would increase both the credibility of the plan and its usefulness as a management tool to enhance accountability. The GRI's plan shows that this information can be presented in an efficient and usable manner.

The multi-year planning process is not based on a systematic review of individual projects by top management to assure federal policy makers that the DOE conservation R&D portfolio reflects current needs and priorities and that outdated and/or weaker projects are terminated expeditiously. Headquarters reviews are important to provide effective management and address potential project termination delays related to shortcomings with Conservation's objectives and milestones.

A uniform prioritization methodology, such as a cost/benefit analysis, used by all DOE conservation R&D program offices would provide decision makers with a sound basis for setting priorities among the four program offices to achieve the best overall program mix.

The inconsistent performance in planning for technology transfer brought out in independent reviews indicates that a more systematic approach is needed, as was suggested by the National Research Council in 1986. Conservation could better assure decision makers that technology transfer received adequate and consistent attention if the program used uniform project and program milestones that emphasized technology transfer, such as those used by GRI.

DOE's conservation planning process would directly support DOE's budgeting needs for information to make incremental funding decisions if plans were developed at varying funding levels that explicitly related funding to specific projects and milestones.

In the past the multi-year plan has served as a communication tool as DOE, through distributing the plan, has solicited and received useful feedback on its planning methodologies and program priorities from DOE offices and laboratories and outside energy and research organizations. This important communication role may be eliminated because Conservation may designate the multi-year plan an internal planning document.

Recommendations

To enhance the usefulness and credibility of the conservation R&D multi-year plan, we recommend that the Secretary of Energy require that detailed program and project information be incorporated in the plan, including objectives and milestones.

We recommend that the Secretary of Energy require that the conservation R&D planning process:

- Include a systematic review of individual projects by top Office of Conservation management to help ensure that the portfolio reflects current needs.
- Use a uniform project prioritization methodology to permit the comparison of the costs and benefits of its proposed activities.
- Include milestones that systematically emphasize technology transfer activities.
- Develop program plans at varying funding levels to provide a link to and support for budgeting needs.

We also recommend that the Secretary require the publication and distribution of the plan internally and externally so that DOE continues to solicit and receive feedback on the plan.

DOE's Conservation R&D Critical Review Program

Ten independent peer reviews of DOE's conservation R&D activities have been conducted under a "critical review" program established by the Deputy Assistant Secretary for Conservation in 1985. According to Conservation officials, many program changes and project terminations have occurred as a result of this peer review process. Our examination of DOE's responses to four of the critical reviews shows that in each case, some recommended changes have been made and others are in the process of being implemented—such as project terminations and redirections. However, because formal follow-up on peer review recommendations is not required, policy makers are not provided with assurance that appropriate actions are taken in response to all critical review recommendations. Despite the management benefits it has provided, the critical review program was de-emphasized in 1989 and could be discontinued as a result of the April 1990 reorganization of the Office of Conservation and Renewable Energy.

Independent Peer Reviews Can Strengthen R&D Management

Independent peer reviews of R&D activities can help ensure the continuing relevance of on-going research activities and sharpen management decision-making. The potential for waste—such as not terminating work at the appropriate time—is a potential research management problem. For example, the Energy Research Advisory Board has noted that one of the reasons it is difficult to terminate federal research activities is that federal R&D programs are generally not oriented to the "bottom line," unlike industry, where programs are terminated when potential economic benefits are found to be too low.[1] Reflecting the assistance they can provide to managers in reviewing federal R&D portfolios, independent reviews of conservation R&D programs have typically recommended some project terminations and redirections. Such advisory recommendations from independent reviews can aid internal program review and budgeting decision-making.

DOE's Critical Review Program

In December 1985, the Deputy Assistant Secretary for Conservation established an independent peer review process—the critical review program—to strengthen management, maintain the quality and vitality of research, and ensure the continuing relevance and focus of the program. The critical review program is directed at "mature R&D projects and programs" and was established as a continuing process to coincide with regularly scheduled program reviews, such as annual contractor

[1] Guidelines for DOE Long Term Civilian Research and Development, Vol. II Infrastructure, DOE Research Advisory Board, Dec. 1985.

presentations. According to the Deputy Assistant Secretary, the program is not intended to provide for periodic review of all conservation R&D programs. Rather, programs are selected for review on the basis of unwritten judgmental criteria, such as duration of research and the amount of funds expended.

When the critical review program was established in 1985, the Deputy Assistant Secretary suggested eight review topics for the first 2-year period and advised the four program offices that projects selected for review should be examined by a panel of four to six experts chosen by him in collaboration with the appropriate office director. Panelists were to be experts in their fields. Suggested technical areas for panelists were manufacturing/engineering, academia, industrial R&D, public sector and nonprofit R&D, and marketing/sales. The panels were to meet one or more times, including an R&D site visit. The Deputy Assistant Secretary directed that each review be completed within 6 months of the start date and that the program offices bear the review costs.

As of February 1990, 10 critical review reports on conservation R&D activities have been issued, as follows.[2]

1. DOE Combustion Technology Program 1986 Peer Review Panel Report.

2. Technical Assessment of the Office of Industrial Programs Advanced Heat Exchanger Program, Apr. 1986.

3. Critical Review of Materials, Walls, and Roof Research Projects of the Building Thermal Envelope Systems and Materials Program, Mar. 1986.

4. Report by the Critical Review Panel on the Department of Energy Heat Engine Propulsion Division Automotive Gas Turbine Project, Jan. 1987.

5. Assessment of the U.S. Department of Energy's Electric Vehicle Propulsion System R&D Program 1986 Peer Review Panel Report, Mar. 1987.

6. Critical Review of the Office of Industrial Programs' Aluminum Research Program, May 1987.

[2]We did not include (1) a peer review of a DOE program that sponsors energy research because it does not involve work planned and managed by DOE or (2) a battery assessment study by DOE laboratories and outside experts that Conservation identified as a critical review because the assessment is fundamentally different from other critical reviews and does not contain recommendations from independent experts.

7. DOE Fenestration Research Program Review Panel Final Report, Mar. 1987.

8. Report of the Critical Review Panel on the Advanced Sensors Program for the Paper Industry, July 1988.

9. An Assessment of the Research Projects in the Buildings and Community Systems Program, July 1988.

10. Report of the Critical Review Panel on the Energy Conversion and Utilization Technologies Materials Program, July 1988.

The Deputy Assistant Secretary gave the program offices some flexibility in designing the reviews, and this latitude has resulted in allowing (1) the review program to meet the specific needs of the offices and (2) the scope and focus of the critical reviews to vary. For example, one program office periodically has an overall program review by the National Academy of Sciences. This office suggested a focused four-project review that was conducted. Another office with no prior overall independent assessment requested an office-wide review that used 15 panels of experts reviewing 118 projects. Some reviews included all projects within a program area and examined up to 70 individual projects. Other reviews were broader; they examined overall program areas but did not examine all of the individual projects within the program.

According to information provided by the program offices, review costs for panelists' fees and travel expenses for 9 of the 10 studies have been minimal, ranging from about $2,000 to $41,000 in total. The most extensive review that examined 15 technical areas in 1 program office incurred panelists' costs of $113,800. This amount is also small, 0.3 percent of the $34 million program funding for that one year.

DOE's Views on the Usefulness of the Critical Review Program

Feedback to the Deputy Assistant Secretary from office directors and program managers on the impacts of the peer reviews is positive. For example, after the program had been in operation for 2 years, the Deputy Assistant Secretary asked for office views on the programmatic impacts of the critical review program. Among the benefits cited were improved project direction, re-evaluations of objectives and strategies, project terminations, and better feedback for technology transfer requirements. The improvements include those in two areas that the

independent reviews often identified as weak: (1) inadequate program and project objectives and (2) technology transfer problems.

In addition to the positive comments from DOE headquarters personnel, laboratory officials at the three sites we visited also endorsed the program. For example, two officials at Oak Ridge National Laboratory cited numerous benefits of one critical review, including prompting meetings with various industry groups to determine technical needs, management needs, and technology transfer needs. Operations office officials also identified benefits, such as providing a fresh evaluation of laboratory projects that can frequently become static.

Critical Reviews Highlight the Need for Individual Project Reviews

While the 10 conservation R&D critical reviews we examined generally endorsed the overall program areas of conservation R&D research, they made numerous recommendations for improvements, particularly at the individual project level. The Report of the Critical Review Panel on the Energy Conversion and Utilization Technologies (ECUT) Materials Program noted this point directly:

> Overall, the Panel strongly believes that the ECUT Materials Program is a commendable federally funded program which shows a potential to make an impact relative to the DOE Conservation mission. The problems the panel sees are more in relation to the selection and execution of specific activities within the main work elements.

The peer reviews included a number of recommendations on project terminations and redirections and on new work to pursue. For example, one review of 118 projects found 24 projects with important deficiencies or major shortcomings that needed to be addressed. Another review report showed that 3 or more of the 6 reviewers concluded that more than one-half of the 58 active projects examined should be redirected or terminated. One review of four projects recommended that all four be terminated for varying reasons, including a technology that did not meet industrial needs and the availability of a similar technology in international markets. Some reviews made recommendations to give certain research activities increased priority support. All of these recommendations can help DOE keep its R&D portfolio focused and up to date.

In addition, the peer reviews also identified some recurring, systemic management problems. Specifically, a majority of the critical reviews cited shortcomings in (1) program and project objectives and milestones and (2) planning for technology transfer of research products.

Inadequate Objectives and Milestones

Clear program and project objectives and milestones are management and evaluation tools that are fundamental to effective management and program success. As we discussed in chapter 2, poor objectives can result in the unwarranted continuation of research activities. While we cannot ascertain the degree to which objectives and milestones were examined in each of the critical reviews,[3] 6 of the 10 reviews identified problems with program or project objectives. The problems were not found with every program and project; however, they are systemic and have been identified in each program office. The reports included some favorable comments on clear objectives and milestones, but negative comments such as the two examples that follow were more common:

> At its current definition, this work element is too vague to define or understand. Based on the assessment, research in this area should be given better definition or else be abandoned altogether. [Excerpt from the Report of the Critical Review Panel on the Energy Conversion and Utilization Technologies Materials Program.]

> It is difficult to connect the stated objective of the program to the current Advanced Heat Exchanger (AHX) program. It is suggested that the AHX Program Manager establish one or two specific goals and organize the funded work to logically support these goals. [Excerpt from the Technical Assessment of the Office of Industrial Programs Advanced Heat Exchanger Program.]

Although program offices reported that critical reviews have, for example, prompted re-examinations of goals and objectives, the Office has not taken steps to ensure that the other programs not subjected to project-level critical reviews can also be improved in these areas. Our recommendation in chapter 2 for systematic headquarters project reviews should provide the impetus for increased attention to the quality of individual project goals and objectives office-wide.

Technology Transfer Shortcomings

Despite Office of Conservation efforts to develop workable technology transfer strategies[4] and the numerous technology transfer activities undertaken by each of the program offices, all of the 10 peer reviews pointed out problems with technology transfer. As discussed in chapter 2, the reports showed that important technology transfer activities, such as identifying user needs, that would effectively promote the commercialization of research efforts were performed unevenly.

[3]As previously discussed, the critical reviews vary in scope and focus.

[4]See DOE-sponsored reports, Technology Transfer Strategies of the U.S. Department of Energy's Conservation Program, Dec. 1988, and Commercializing Government-Sponsored Innovations: Twelve Successful Buildings Case Studies, Jan. 1989.

The criticisms in the reviews generally reported weaknesses in (1) identifying user needs, that is, technology, information, or economic (cost) requirements; (2) keeping up to date on market needs and activities; or (3) disseminating DOE research results to the proper audiences. Examples of review comments follow.

> The approach . . . is good; however, the panel is uncertain about who will use these techniques. The project should clearly identify possible users. [Excerpt from An Assessment of the Research Projects in the Buildings and Community Systems Program.]

> As regards the other three programs, systems performing the same function appear to have been successfully commercialized since the start of DOE-sponsored programs. The broadly applicable results from these three programs, however, may form the basis for research in other directions. [Excerpt from the Report of the Critical Review Panel on the Advanced Sensors Program for the Paper Industry.]

> The panel recommends an increased information dissemination effort to ensure that the research and industrial communities are made aware of the program's activities and accomplishments. The one-pagers or research summaries put together for the critical review are steps in the right direction. Some panel members have indicated they were unable to obtain similar program information in the past. [Excerpt from the Report of the Critical Review Panel on the Energy Conversion and Utilization Technologies Materials Program.]

These observations, together with the other comments in the independent reviews indicating technology transfer weaknesses, reflect the need for a more systematic approach to achieve consistency in this important area. To provide an appropriate framework, our planning recommendations in chapter 2 include a requirement that conservation R&D milestones emphasize technology transfer activities.

DOE Does Not Routinely Monitor and Document Responses to Critical Review Recommendations

DOE may inadvertently overlook some relevant critical review recommendations or fail to implement them in a timely manner because (1) formal monitoring of DOE responses and actions taken in response to recommendations is not done at headquarters and (2) documentation and communication of responses is limited. For example, when a peer review report is issued, the Deputy Assistant Secretary has directed that the program office prepare a memorandum to the Assistant Secretary outlining the review recommendations along with the office's initial reactions. In our four case studies, we found that in one instance, no such response was prepared. In the three other cases, we found that the

responses did not address all of the reports' recommendations. Implementation of critical review recommendations is delegated to the individual program managers, and monitoring of responses is not done at the Assistant Secretary, Deputy Assistant Secretary, or program office level at headquarters.

Documentation that links current program plans to the prior recommendations generally was not available. For three of the reviews, officials could not provide documentation that showed how the recommendations had been addressed. While DOE headquarters, operations office, and laboratory personnel were able to provide program plans and statements of work and verbally relate certain activities to critical review recommendations, this informal approach relies primarily on managers' recollections.[5] The rationale for making or not making changes is not clearly documented, and future actions and changes are therefore at risk of being overlooked with the passage of time and staff changes.

Furthermore, this unstructured, informal response to peer reviews can create uncertainties and misunderstandings among those managing and conducting the research. For example, during our examination of DOE responses to two of the critical reviews, Oak Ridge National Laboratory and Oak Ridge Operations Office officials said that they had received no guidance from headquarters on how to respond to the recommendations and, more importantly, that they received little feedback from DOE headquarters as to whether actions already taken or planned were appropriate and adequate to satisfy the independent review recommendations.

While a separate monitoring system may not be warranted for the critical review program alone, we believe that a more systematic, documented response is needed to fully reap the benefits of these independent assessments. In chapter 2, we recommend that systematic, documented reviews of individual projects be conducted annually at the headquarters level. Responses to peer review recommendations could be systematically examined within this review process.

[5]We were able to determine that some of the recommendations in each of the critical reviews examined have been and/or are being implemented.

Critical Review Program May Be Terminated

The program has been de-emphasized recently, and it may be terminated as an office-wide review process. At inception, one peer review per program office per year was planned. The last critical review was completed in July 1988. While the Deputy Assistant Secretary recommended topics for fiscal year 1990 reviews, the peer reviews were delayed because of uncertainties surrounding the reorganization, according to the Special Assistant to the Deputy Assistant Secretary.

Now that the April 1990 reorganization has occurred, the critical review program may be terminated as a program-wide effort. Before the reorganization, the four conservation program offices reported to the Deputy Assistant Secretary who initiated the critical review program. Now, four deputy assistant secretaries have conservation R&D responsibilities. The Assistant Secretary said that the deputy assistant secretaries must follow broad management guidelines he has developed, but that he will rely on each of them to determine how their programs will be reviewed.

It is possible that some offices will continue with this program, but continuation cannot be assumed. For instance, prior to the reorganization, one office director stated frankly that his office would not conduct critical reviews without being directed to by the Deputy Assistant Secretary. His view was that he would rather spend his limited funding on research rather than evaluations. Another office director responded to a Deputy Assistant Secretary request for review topics in 1987 by indicating various reasons why he did not think another review was needed. According to the Special Assistant to the Deputy Assistant Secretary, the program offices needed to be pushed to do peer reviews because they require a lot of staff time and, of course, the results could be critical of the work reviewed. On the basis of these views, we conclude that a mandate from top management to conduct independent peer reviews is necessary to continue the program office-wide.

A program official provided an additional reason why the program should be required by top Conservation management. He noted that the involvement of managers outside of the program offices, particularly the selection of the review panel members, provided a level of independence that added to the credibility of the process. He also said it was important that the peer review results be communicated directly to the Assistant Secretary by the review panel chairman, as occurred in most instances.

Conclusions

In our view, the critical review program should be continued. It has provided DOE with guidance from independent experts on the continuing relevance of its conservation research efforts, at minimal cost for reviewers' expenses. The peer reviews have generally endorsed the research program areas, while recommending some program redirection and numerous individual project terminations or changes.

Documentation and communication of DOE actions in response to the critical reviews are limited. If DOE and the Congress are to have assurance that all appropriate recommendations are implemented in a timely manner, peer review recommendations should be specifically addressed in the systematic, documented, individual project reviews we recommend in chapter 2. Addressing peer review recommendations within this system could help ensure that the recommendations are uniformly evaluated by DOE management and implemented, as appropriate, in a clear, consistent, and expeditious manner.

Recommendation

To ensure that conservation R&D programs continue to receive independent reviews under the revised organizational structure of the Office of Conservation and Renewable Energy, we recommend that the Secretary of Energy require the cognizant deputy assistant secretaries to implement independent peer reviews annually and to examine peer review recommendations as part of the Office's multi-year R&D planning process.

Federal Conservation R&D Successes

The Department of Energy (DOE) conservation research and development (R&D) program has produced some technologies that are providing energy efficiency benefits resulting from relatively small federal investment. For example, a partial listing of technology successes prepared for the fiscal years 1991-95 draft multi-year plan includes 13 technologies with total DOE costs of $21 million and related energy cost savings of $11 billion projected to the year 2010.[1] More than half of the projects cost less than $1 million.

While selected conservation success stories are identified in DOE publications, little information is provided on economic costs and benefits. One report, A Compendium of Energy Conservation Success Stories, highlights 90 successful conservation R&D projects but does not identify these projects' costs relative to the projected energy savings.[2] Some of the successes identified in periodicals and DOE publications are discussed below. Information on related costs and benefits is provided in the cases where such information is provided in the reports examined.

Two DOE conservation-supported technologies were cited in a technology publication as among the 20 key developments of the 1980s.[3] Research done by DOE's Office of Energy Research and the Conservation Offices of Energy Utilization and Transportation Systems led to the development of the technologies. The successes are two materials that overcome an impediment to the development of advanced energy-conserving technologies—the lack of materials capable of withstanding high temperatures, high pressures, and highly corrosive environments. The materials developed are (1) nickel aluminide superalloys that are currently licensed to five companies for use, among other things, in heavy duty truck engine components, electrical heating elements, and aircraft fasteners and (2) ceramic composites that have, among other uses, been licensed to nine companies for use as cutting-tool inserts and also have been fabricated into a number of heat engine components.

Other examples of key commercialized technologies that are expected to achieve wide market use include windows and lighting technology

[1]We did not evaluate the DOE cost and energy savings estimates. However, seven case studies prepared by the American Council for an Energy-Efficient Economy in 1987 also reported small DOE investments with significant energy savings potential.

[2]Other publications describing successful R&D projects include Commercializing Government-Sponsored Innovations: Twelve Successful Buildings Case Studies, Jan. 1989, and Programs in Energy Conservation, Dec. 1988.

[3]"Technology's Hits and Misses of the 1980s," High Technology Business, Nov.-Dec. 1989.

resulting from Office of Buildings and Community Systems research. For example, the buildings program funded the development of low emissivity (Low-E) glass coatings for windows that reduce a major source of energy loss in buildings. This technology can reduce the heating, cooling, and lighting requirements associated with windows by 20 to 40 percent. According to DOE data, this project cost $1 million and may provide energy cost savings of $2.5 billion projected to the year 2010. Another DOE technology (solid-state ballasts for fluorescent lighting) improves lighting efficacy by 25 percent. Working with two contractors, DOE developed and tested this technology at a reported DOE cost of $0.6 million; potential energy cost savings are estimated to be $3.3 billion by 2010.

Among the successful research projects that the Office of Industrial Programs monitors are a slot forge furnace that offers energy savings of 50 percent or more, a high-efficiency welding unit, and a low-speed diesel cogeneration system. According to DOE, these three projects cost $14 million and have projected energy cost savings of $1.3 billion. The Office of Industrial Programs reports that more than 25 of its projects have resulted in technologies that are currently in use by industry, providing annual energy savings of more than $161 million.[4]

DOE also reports that the Office of Transportation produced the first electric vehicle with a range of over 100 miles, ceramic turbine rotors that allow practical application of turbocharger technology, and ceramic coating for diesel components that will yield a direct fuel economy benefit of nearly 4 percent for advanced diesel engines.

[4]Summary of Program Impacts, Industrial Energy Conservation, Mar. 1990.

The Gas Research Institute R&D Planning Model

The Gas Research Institute (GRI) is a nonprofit research management organization that plans and manages predominately applied energy R&D activities to benefit the natural gas industry and its customers. GRI, using a centralized management structure, managed over 200 research projects in 1989. Annual funding for GRI, $175 million in 1989, closely approximates that of DOE's conservation R&D program. GRI's planning and management processes have been endorsed by the National Research Council as being effective and competent.

In chapter 2, we discussed five shortcomings in the DOE conservation R&D planning process. In each of these five areas, discussed below, the GRI planning process offers alternative, workable approaches that would overcome DOE's weaknesses.

Individual Project Information

As part of its program area descriptions, the GRI plan succinctly identifies the individual projects being proposed and their related overall objectives and costs. Milestones and critical decision points are included for the individual projects for the preceding 2 years and 5 years forward. In addition, for each project area, the GRI plan discusses accomplishments of the prior year, its research and technology transfer strategy, significant impacts of program reviews, co-funding planned from outside organizations, and relevant coordination activities with other organizations.

Individual Project Reviews

GRI uses a senior management committee, called the Senior Research Council, to oversee its planning process in terms of project-level-and-above budgets, strategic emphasis, program direction, and review of R&D progress and goals. The six-person committee includes three executives who report to the GRI President and the three executives who manage the research offices and report to the Senior Vice President, R&D.[1] On the basis of extensive project reviews, the Senior Research Council makes recommendations for (1) terminating concepts due to lack of progress, (2) moving funding into or out of concepts to ensure that critical activities are "fully funded," or (3) revising concept goals and/or milestones.[2] Written "action items" document the decisions made at these meetings.

[1]Senior Research Council members are the Senior Vice President, R&D Management, the Vice President for Technology Transfer and R&D Administration, and the Vice President/Chief Scientist who report to the GRI President; and the three vice presidents responsible for the research offices who report to the Senior Vice President, R&D.

[2]GRI's management structure is organized around concepts, a lower level of research classification than projects. For example, a project typically includes several concepts.

GRI also uses a computerized data base that provides summary information about all of its R&D concepts. The GRI data base includes the concept objective, a description of the work, funding history, milestones, a summary status report, and the date of the latest data base revision.

Uniform Prioritization Methodology

GRI uses a uniform, quantitatively based system for prioritizing its diverse project areas—supply options, end use, gas operations, and cross-cutting research. Each GRI candidate project area is assessed at four funding levels with respect to five appraisal criteria. Expected benefits at the various funding levels are derived using weighting factors for the criteria and the probability of achieving technical and commercial success. The process analyzes the marginal benefit of each incremental funding level and results in a prioritized project listing based on the cost-benefit measure developed in the process. Assumptions used in the analysis are documented and available for later review.

Using this uniform methodology, GRI produces a listing of R&D alternatives ranked in order of decreasing benefit-to-cost ratio. This listing is judgmentally adjusted by GRI senior management, board of directors, and advisory bodies, and provides the basis for GRI's annual 5-year R&D plan.

GRI Milestones Emphasize Technology Transfer

Among GRI's technology transfer principles is a well-conceived technology transfer strategy and plan; these plans are systematically considered and emphasized by GRI's use of uniform milestones and decision points. The standard milestones and decision points GRI uses in its plan for all applied research projects are presented in table 2.1, with the points that relate most specifically to technology transfer highlighted. GRI uses its milestones in planning and managing its research as appropriate, and this often means re-visiting earlier milestones. For example, the second milestone requiring an evaluation of existing information, including economic/technological trade-offs, may occur at several different points along the multi-year period presented in the plan. This approach helps ensure that all program managers are routinely planning for and conducting technology transfer activities from project initiation to conclusion.

Table II.1: GRI's Standard R&D Milestones and Decision Points

Milestones		Decision points	
1	Assess R&D needs including potential applications, general technical requirements, and pertinent economic factors.	S	Select most promising concept for further development.
2	Evaluate existing information to provide an understanding of the fundamental relationships and economic/technological trade offs among key parameters.	G	Go/no-go decision.
3	Conduct focused experimental data acquisition program to provide information necessary to develop an understanding of the fundamental relationships among key parameters.	F	Initiate field test.
4	Design, assemble, and conduct "laboratory-type" tests to identify relationships among key components or key operations.	P	Achieve proof-of-concept.
5	Design, construct, and conduct limited field experiments or laboratory experiments to verify the performance of key components or subsystems.	T	Transfer technology or information for application.
6	Conduct field tests to verify system performance under realistic operating conditions.	D	Discontinued or deferred R&D effort.
7	Transfer significant intermediate R&D results to external audiences/industry	E	Initiate field experiment.
8	Apply information from other GRI projects/project areas.		
9	Transfer information to other GRI projects/project areas.		

Source: Gas Research Institute 1990-1994 Research and Development Plan and 1990 Research and Development Program.

Funding Estimates

The GRI R&D plan is formulated after consideration of four funding levels for each project area (grouping of related projects). Each project area is examined at a funding level that would maintain, increase, decrease, or terminate funding. Specifically, the funding levels developed would (1) maintain the existing schedule to achieve objectives; (2) provide achievements at a more rapid pace or with less technical risk; (3) achieve objectives at a later date or with reduced probability of success; and (4) assume no GRI funding.[3] This methodology directly links funding amounts and time frames and supports budgeting needs by presenting the research activities that can be conducted at varying funding levels.

[3]Assuming no GRI funding forces the staff to estimate when the technology would be introduced if the research effort were left to others. This time estimate identifies the technology development acceleration that may be achieved by direct GRI support.

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