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Briefing Report to the Chairman, Subcommittee on Research and Development, Committee on Science, Space, and Technology, House of Representatives

May 1990

ENERGY R&D

DOE's Allocation of Funds for Basic and Applied Research and Development

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Resources, Community, and
Economic Development Division

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May 24, 1990

The Honorable Marilyn Lloyd
Chairman, Subcommittee on Energy Research
and Development
Committee on Science, Space, and
Technology
House of Representatives

Dear Madam Chairman:

On August 31, 1989, you requested information on the Department of Energy's (DOE) process for allocating energy research and development (R&D) funds. In fiscal year 1990, DOE's budget for R&D efforts encompassing programs in fossil, nuclear, solar, fusion, and renewable energy sources as well as basic energy sciences and energy conservation was over $4 billion. Section 1 contains a short history of DOE's energy R&D efforts.

Specifically, you asked us how DOE prioritizes and coordinates funding requests among the various research and development program areas, including the role, if any, of the Office of Management and Budget (OMB) and DOE advisory groups. You also asked how priorities have evolved over the past 10 years, how the overall DOE funding for R&D has been distributed between basic research and applied research and development, and how much DOE has invested in major demonstration projects over the past 10 years.

We briefed your office on the information in this report on February 15, 1990. In summary, we found the following:

- OMB budgetary targets and DOE's budget process determine how R&D funds are allocated. Funding priorities are set within the program areas according to budget guidance and general policy statements. According to DOE officials, DOE has had no good way to establish budget priorities. However, DOE is developing a national energy strategy which it plans to submit to the President by December 1990. During the 1980s, OMB budgetary targets played an important role in reducing funding for the applied technology areas of fossil, nuclear, conservation and renewable energy R&D which was in accordance with the policy of undertaking long-term, high-risk research. DOE primarily coordinates its R&D agenda during the budget process through analyses of energy areas for broad issues that cut across program areas. The major advisory group in DOE

was the Energy Research Advisory Board which, at the Secretary's request, advised and made recommendations on various energy R&D issues. (See section 2.)

- Over the past 10 years, energy R&D priorities have shifted from the energy technology program areas of fossil, nuclear, conservation, and renewable R&D to the basic energy research program areas of general science and basic energy sciences.[1] While the energy technology program areas decreased almost 45 percent from 1980 to 1990, the basic energy research program area increased over 140 percent. In addition, from fiscal year 1983 to 1990, congressional appropriations for the energy technology areas influenced priorities because they were generally greater than DOE requested, although not at a level sufficient to maintain the funding levels of the early 1980s. (See section 3.)
- Over the past 10 years, funds for basic research have increased greatly, while funds for applied research have increased slightly and funds for development have decreased significantly. DOE's budget for basic research increased over 186 percent during this period, while the applied research budget increased about 17 percent and the development budget decreased 39 percent. (See section 4.)
- From the mid 1970s through 1990, over $6 billion has been invested in demonstration projects. Of the 41 projects, 15 were terminated, 9 were completed, and 17 are ongoing. Of the 15 terminated projects, 10 were terminated because the previous administration decided not to fund demonstration projects. Of the other five, two were terminated due to production problems, two were terminated due to a lack of financing on the part of the private enterprises proposing to do the projects, and one was terminated by the Congress. (See section 5.)

Appendix I contains a detailed list of DOE's demonstration projects.

We conducted our review from September 1989 to February 1990 in accordance with generally accepted government auditing standards. Our objectives, scope, and methodology are contained in section 6. In discussions with DOE, they generally agreed with the results of our work.

As arranged 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 of this briefing report to the appropriate House and Senate committees, the Secretary of

[1]The energy technology program areas generally perform applied research and development, although a small portion of their funds are used to carry out basic research.

Energy, and the Director, Office of Management and Budget. Copies will also be made available to other interested parties who request them.

Should you have questions or need additional information, please contact me on (202) 275-1441. Major contributors are included in appendix II.

Sincerely,

Victor S. Rezendes
Director, Energy Issues

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Abbreviations

DOE	Department of Energy
ERAB	Energy Research Advisory Board
NES	National Energy Strategy
OER	Office of Energy Research
OMB	Office of Management and Budget
R&D	research and development

Background

Federal support for civilian energy research and development (R&D) has moved through several phases since the early 1970s, reflecting changes in both international energy markets and government policy. During the 1970s the federal government focused its support on the nation's developing civilian nuclear reactor industry. However, this limited federal energy R&D role increased greatly after the Arab oil embargo and subsequent energy crises during the 1970s. The government retained its nuclear R&D role and developed and expanded programs in renewable energy, fossil energy, and conservation through the end of the decade. The government not only increased its support for R&D on alternative energy technologies but also broadened its role in energy to support demonstration and commercialization of emerging technologies. As a result, the energy R&D budget increased from $622 million in 1973 to about $4.7 billion in fiscal year 1981, a nearly eightfold increase.

In January 1981, the new administration had a different philosophy of the government's role in energy. It proposed an energy program which significantly altered the previous administration's program. It believed that the government's energy program should be limited to performing only long-term, high-risk, and high-payoff R&D which industry could not be expected to undertake. It was predicated on the assumption that as a technology moves closer to demonstration and commercialization, the government's role should be curtailed with industry providing financial support. Thus, the free marketplace was expected to supply the capital investments required to support the demonstration and commercial introduction of new and alternative energy technologies into the economy. The administration believed that the marketplace could achieve this introduction more efficiently and effectively than the government, especially if energy prices were allowed to reflect their true replacement costs.

In support of this belief, budget authority for DOE's Basic Energy Research program and supporting research activities rose from $1.2 billion in the fiscal year 1980 budget to $2.4 billion in the fiscal year 1990 budget—an increase of 93.2 percent. Budget authority for the other energy technologies—fossil, renewable, conservation, and nuclear R&D—dropped about 46 percent during the same period from $3.1 billion to about $1.6 billion. For fiscal year 1990, DOE received total R&D appropriations of over $4 billion. Table 1.1 shows the program areas and their fiscal year 1990 appropriations.

Table 1.1: Program Areas for DOE R&D and Funding for Fiscal Year 1990

Program Area	Appropriation	Total
Basic Energy Research		
General Science	$1,093,316	
Basic Energy Sciences	569,837	
		$1,663,153
Supporting Research Activities		
Biological and Environmental Research	308,693	
Other Supporting Research Activities	96,527	
		405,220
Magnetic Fusion		320,259
Nuclear Energy		341,847
Clean Coal Technology		554,000
Fossil Energy R&D		
Coal	275,259	
Gas	14,429	
Petroleum	39,913	
Other Fossil	88,670	
		418,271
Conservation and Renewables		
Conservation	194,069	
Solar	89,659	
Renewables	47,952	
		331,680
Total		**$4,034,430**

DOE's Prioritization Process for R&D Program Areas

OMB budgetary targets and DOE's budget process determine the allocation of funds appropriated for R&D. Priorities are set within the program areas according to DOE and OMB budget guidance and general policy statements. DOE's research agenda is primarily coordinated during the budget process. The Energy Research Advisory Board made recommendations to the Secretary of Energy on various aspects of energy research and development which were adopted to some extent by DOE.

OMB Role in Allocating R&D Funds

OMB plays an important role in the allocation process through its setting of budgetary targets. According to DOE officials, DOE provides out-year[1] budget projections to OMB during the annual budget process. According to DOE's Controller, these out-year projections are developed using the budget year as a baseline and adjusting for inflation and for whether program requirements are expected to go up or down. OMB reviews and adjusts DOE's projections and provides DOE with budget planning ceilings, i.e., targets, in annual budget guidance letters, which state the administration's goals in broad terms. For example, for fiscal year 1988, the letter stated that

"The 1988 Budget continues to emphasize longer term, high risk Non-Nuclear Energy Research and Development that broadly supports private development of new energy production and conservation technologies. Within Fossil Energy, there is a relatively greater emphasis on acid rain-related technologies and enhanced oil recovery." [Emphasis in original.]

The guidance letters also contain out-year estimated targets. For example, the 1990 budget guidance letter contained out-year numbers for 1991 through 1993. The out-year number becomes the starting point for the next year's budget. The targets are updated in the late summer before the next fiscal year begins. According to OMB officials, the new target is based on the previous year's budget, and the out-year numbers are projected assuming the policies and programs of the current year.

Budget Process Determined Priorities

During the 1980s, the assistant secretaries for the program areas were responsible for setting the priorities within their areas based on budget guidance and administration policy. DOE published a National Energy Policy Plan in 1981, 1983, and 1985, and a report entitled Energy Security in 1987, which contained general policy statements on energy research and development. Throughout the 1980s, the policy was to

[1]Out years are future budget years.

undertake long-term, high-risk research and to concentrate federal energy R&D in areas where the incentives for and availability of private investment were severely limited or nonexistent. Under these policy plans, program areas were not compared and priorities were not set across the range of programs. DOE stated in its posture statement to its fiscal year 1991 budget overview that "the Department had no road map for developing top-down policy guidance. There was no Department-wide five-year program plan and no good way to establish budget priorities."

For fiscal year 1991, DOE stated that it would no longer focus only on "long-term, high-risk R&D" but would reflect a proper balance of basic and applied R&D specifically directed toward national energy goals. Also, the research programs should look for areas with the greatest potential for a scientific or technological breakthrough that could significantly advance the technology and competitiveness in the market. DOE also stated that the objective in prioritization should be to look for the best pay-off in achieving energy, environmental, and safety and health goals.

At the beginning of the budget process, the DOE Under Secretary issues a budget guidance memorandum that includes OMB targets for each program area. For fiscal year 1991 the guidance stated, among other things, how the budget would be focused and how the priorities would be set. The fiscal year 1991 budget guidance stated that each program would be developed to show how it contributed to achieving DOE goals in the near term, mid term, and long term. The national goals were to promote health and safety, a clean environment, energy security, U.S./world competitiveness, and national defense.

Using the Under Secretary's budget guidance, the assistant secretaries develop their program area budgets. As part of this budget formulation process, priorities are set at three levels—at a decrement, at target, and at program planning. The decrement is the difference between the target and a percent reduction from the target, and program planning level consists of proposed initiatives above the target. In the past the decrement level was 10 percent, but for fiscal year 1991 the decrement level was increased to 15 percent. Each assistant secretary receives budgetary targets from the Under Secretary that are based on the targets set by OMB. The targets are by decision unit which DOE defines as a program entity for which various funding requests may be developed. Examples of decision units would be light water reactors under Nuclear Energy R&D and coal liquefaction under Fossil R&D. The assistant secretaries can

rerank the funds for their decision units as they see fit; however, the bottom line total must tie directly to the target.

According to DOE's Controller, during the 1980s any changes to the priorities set by the assistant secretaries were done "at the margin," i.e., the interval between the target and the 10-percent decrement. The budget office would scrutinize each assistant secretary's budget, challenge new initiatives, and recommend a funding level below the target. This difference resulted in discretionary funds which the Secretary of Energy could move from one program area to another. The assistant secretaries could appeal decisions not to fund projects, but the Secretary made the final funding decisions on each program. However, according to the Controller, individual program initiatives were not compared across program areas. The idea was to do some research in each of the program areas. In addition, according to a DOE policy official, the Secretary did not have any master plan for energy programs.

The Controller stated that during the fiscal year 1991 budget cycle, the Secretary had a pre-budget review in which he discussed the near-, mid-, and long-term goals for each program area with the responsible assistant secretary and the DOE Office of Budget and provided guidance on each program area's ideas. The assistant secretaries then put together their budgets. After the budget office reviewed the budgets, the assistant secretaries could appeal any budget office revisions to the Secretary. The Secretary made the final decisions after listening to the assistant secretaries who had issues to resolve.

In July 1989, DOE announced the development of a National Energy Strategy (NES) that is intended to be a blueprint for energy policy and government program decisions. The objectives of the NES are to

- rely on market principles to the greatest extent possible,
- encourage a mixed and balanced set of energy supply resources,
- promote increased energy efficiency where cost effective, and
- minimize potential effects to the environment from energy production and use (including acid rain and global warming) wherever this is cost effective or justified for other reasons.

DOE issued an interim report in April 1990 and is scheduled to issue a final submission to the President by December 1990. A DOE policy official told us that the NES will be used to make program and budget decisions and will be out in time to influence fiscal year 1992 budget decisions.

Coordination of Research Agenda

DOE coordinates the R&D agendas among the various research program areas during the budget process to avoid duplication of funding and research effort. At that time, the budget office coordinates R&D issues across program areas (crosscutting) by preparing an analysis of that issue with input from the program offices. This analysis involves (1) identifying other program offices that do research on the same issue (e.g., high temperature superconductivity, geosciences, global climate change, acid rain, and biofuels), (2) determining how much funding each office obtains for that issue, and (3) determining each office's research focus. For example, biofuels[2] is an issue in which two offices carry out research—Energy Research and Conservation and Renewable Energy. The analysis for this issue stated that the Office of Energy Research focused its research on providing fundamental biological information on plants and microorganisms for new energy biotechnologies while Conservation and Renewable Energy focused its research on the growth of feedstock—wood and plants—and new conversion processes. Thus, this particular analysis concluded that each of the program areas focuses on a different level of research effort.

We also found that some coordination is done by the program areas outside of the budget process. For example, a planning official in the Office of Fossil Energy told us that his office coordinates with Conservation on fossil technology. He believed that aside from this there was not much danger of Fossil R&D overlapping other R&D within DOE. In addition, an Office of Energy Research official told us that at the request of the assistant secretaries, the Office of Energy Research routinely conducts evaluations of programs to identify gaps and overlapping research areas. These evaluations are internal and are issued to the assistant secretaries for their action.

Role of Advisory Groups in Allocating R&D Funds

DOE's major advisory group for energy R&D was the Energy Research Advisory Board (ERAB). The Board's role in the allocation process was to advise the Secretary on issues relating to DOE's R&D. In this role ERAB issued three reports concerning the priorities for DOE's R&D. The first report made recommendations for budgetary priorities; however, the second and third reports did not.

The first report, Federal Energy R&D Priorities, was dated November 1981. The report evaluated four major energy sectors for overall federal

[2]Biofuels are fuels obtained from living matter, especially plants and plant products. Biofuels involves growing more and better vegetation and converting this vegetation to fuel.

energy R&D priorities for: electric supply, liquid fuels and gas supply, conservation and utilization, and science and technology base. It concluded that funding for R&D for electric supply and liquid and gas supply technologies was higher than needed, that funding for conservation should be increased, and that funding for certain areas of the science and technology base should be increased. In August 1986, DOE's Argonne National Laboratory issued Case Studies of DOE Response to ERAB Recommendations: A Retrospective Analysis which stated the following conclusions:

- In science and technology base, DOE apparently agreed with ERAB's general high priority assessments.
- In electric supply, funding had dropped significantly, especially in areas ERAB assigned a low priority.
- In liquid and gas supply, DOE funding patterns had been in general agreement with ERAB recommendations.
- In conservation and utilization, ERAB had in general indicated a higher priority than was evident in DOE appropriations.

ERAB's February 1983 report, The Federal Role in Energy Research and Development, considered only one criterion, appropriateness of the federal role, and evaluated each of DOE's major energy R&D programs against this criterion. It contained no specific funding recommendations. It categorized the federal role as primary, complementary, or minimal. The August 1986 case studies report concluded that in the years since the 1983 report, DOE funding shifted to reflect these role definitions, and in fiscal year 1987, the items that ERAB ranked primary received the strongest budget recommendations, while funding for those ERAB ranked minimal had been significantly reduced.

ERAB's December 1985 report entitled Guidelines for DOE Long-Term Civilian Research And Development summarized the work of four subpanels that dealt with energy supply, energy demand, energy research, and DOE R&D infrastructure. ERAB recommended three high priority national goals to (1) reduce U.S. long-term dependence on foreign oil; (2) assure an adequate supply of economical, safe and environmentally acceptable electric power; and (3) to continue the development of a strong national basic science base. ERAB also recommended that DOE dramatically upgrade its research and development management capabilities.

The August 1986 case studies report stated that because of the recentness and complexity of the 1985 ERAB report, an analysis of DOE's

responses was not possible. Our analysis of the 1985 report showed that DOE's response to the recommendations was mixed. For example, one specific recommendation was that DOE scale up research in geosciences. A DOE official told us that an Office of Geoscience Research has been established within the Office of Fossil Energy. In the area of renewable energy, ERAB stated that certain technologies warrant substantial DOE support. Funding for renewable energy continued to decline through the late 1980s.

In the 1985 report, ERAB recommended that DOE establish a strategic planning process as the primary means for determining its R&D goals and for establishing R&D priorities. However, in its fiscal year 1989 Federal Managers' Financial Integrity Act report, DOE stated that it had no comprehensive strategy for conducting its energy programs. DOE's proposed corrective action is to develop the National Energy Strategy by December 1990. In addition, a DOE Office of Energy Research official told us that the National Energy Strategy, currently being developed by DOE, is indirectly carrying out some of the recommendations in the 1985 ERAB report.

In addition to ERAB, two other groups—the National Petroleum Council and the National Coal Council—do studies at the Secretary's request. A representative of these groups told us that neither Council influences the process for allocating R&D funds in DOE.

Evolution of DOE R&D Priorities From 1980 to 1990

Although DOE's policy plans did not state specific priority areas for energy R&D, requested and actual appropriations clearly show that DOE's priority shifted during the last 10 years toward the Basic Energy Research program area and away from research in energy technology program areas. In addition, from fiscal year 1983 to 1990, congressional appropriations for the energy technology program areas influenced priorities because they were generally greater than DOE requests, although not at a level sufficient to maintain the funding levels of fiscal years 1981 and 1982.

In examining DOE appropriations, we found that, in actual dollars, funding for Basic Energy Research increased almost 140 percent from $694.8 million in fiscal year 1980 to $1.7 billion in fiscal year 1990. The Basic Energy Research program area includes research activities in basic energy science, high energy physics, nuclear physics, and biological and environmental sciences. The research is generally basic in nature, which DOE defines as systematic, fundamental study directed toward fuller scientific knowledge or understanding of subjects bearing on national energy needs.

From fiscal year 1980 to 1990, research and development funding decreased for the program areas directed toward specific energy technologies, which includes Fossil, Nuclear, Renewable Energy, and Conservation R&D. Fossil Energy R&D funding decreased over 50 percent, Conservation R&D decreased 34 percent, and Renewable Energy R&D funding decreased over 83 percent. Nuclear Energy R&D funding also decreased over 68 percent. The research in the energy technology program areas is generally applied and development in nature. DOE defines applied research as systematic study directed toward fuller scientific knowledge or understanding for direct use in fulfilling specific energy requirements. DOE defines development as the development and test of systems and pilot plants judged to be technically and economically desirable as a means of achieving principal departmental goals.

As figure 3.1 shows, the percent change in funding for energy R&D programs adjusted for inflation from fiscal year 1980 to fiscal year 1990 was dramatic.[1] In addition, as shown in figure 3.2, Basic Energy Research's share of total energy R&D appropriations increased from 16.2 percent in fiscal year 1980 to 41.2 percent in fiscal year 1990.

[1] Adjustments for inflation are made to provide a clearer comparison of appropriations over time.

Figure 3.1: Percent Change in Funding for Energy R&D Programs Between 1980 and 1990 (In Constant 1989 Dollars)

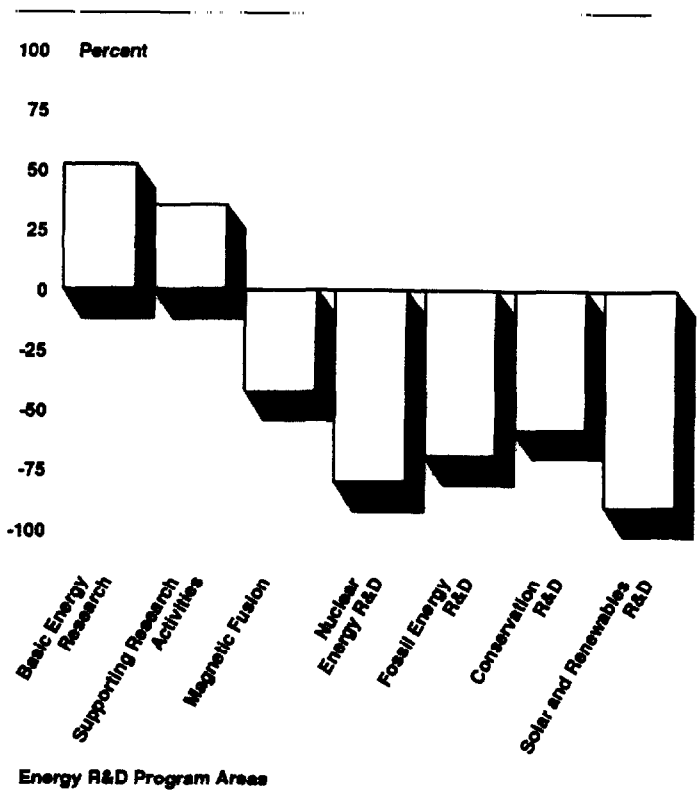
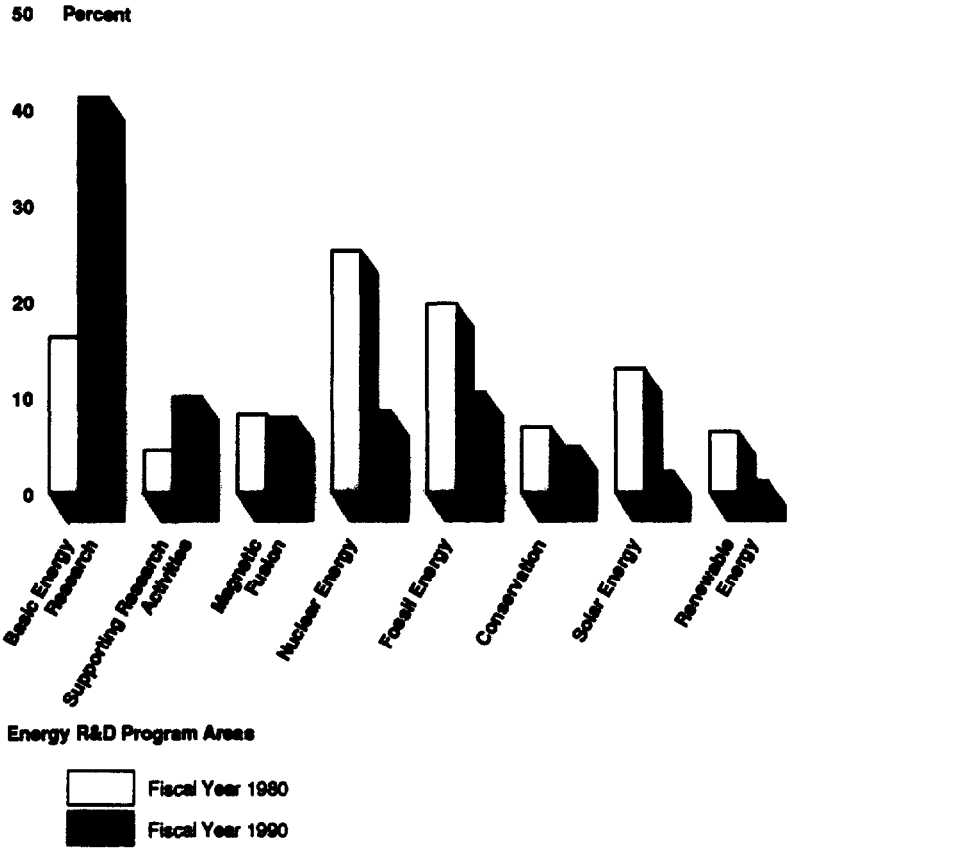


Figure 3.2: Change in Percent of Total for Energy R&D Programs From 1980 to 1990

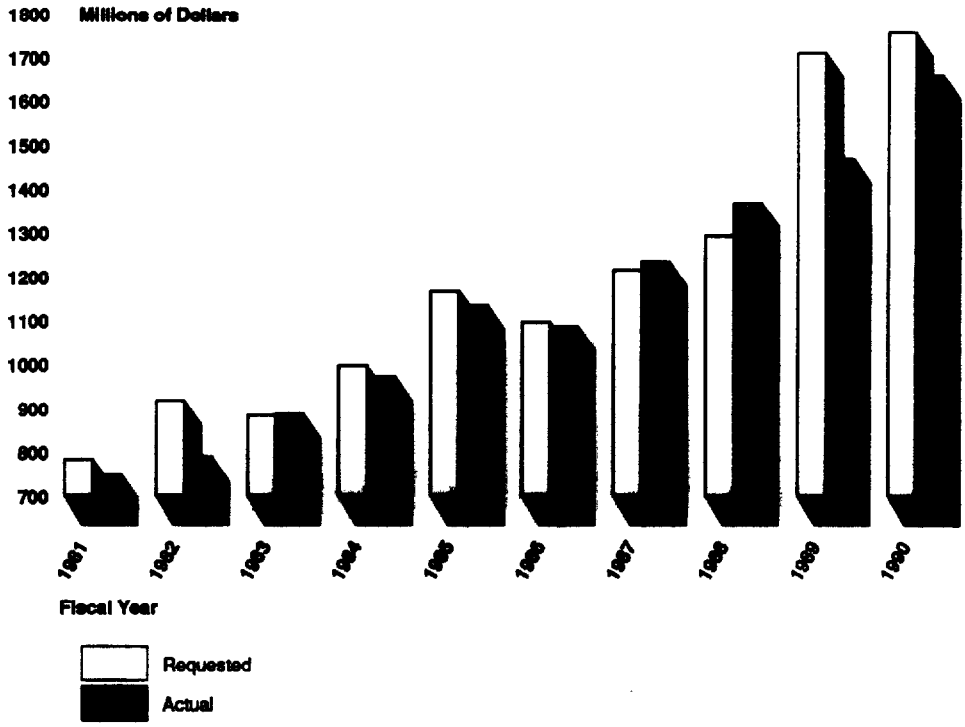


Basic Energy Research and Supporting Research Activities

Basic Energy Research fared well during the 1980s with an increase in actual dollars of almost 140 percent — from $694.8 million in fiscal year 1980 to $1.7 billion in fiscal year 1990. Adjusting for inflation, this increase in funding was over 52 percent. Programs included in this category are General Science Research and Basic Energy Science. General science activities consist of three major programs: High Energy Physics, Nuclear Physics, and the Superconducting Supercollider, all of which are concerned with basic research into the fundamental forces of nature. The Basic Energy Sciences program is responsible for generic, long-range energy related research in support of both nuclear and nonnuclear energy technologies. The administration showed its support for these

areas in budget requests. Figure 3.3 shows the difference in the administration's request and the actual appropriations for these areas from fiscal year 1981 to fiscal year 1990.[2]

Figure 3.3: Requested Versus Actual Appropriations for Basic Energy Research for Fiscal Years 1981 to 1990



Supporting Research Activities also fared well with an increase in actual dollars of over 100 percent, from $191.3 million in fiscal year 1980 to over $405 million in fiscal year 1990. Adjusted for inflation, the increase was about 35 percent. Supporting Research Activities include such areas as biological and environmental research, university research support, and multiprogram energy laboratories facility support. Biological and environmental research, which seeks to develop the knowledge necessary to identify, understand, and anticipate the long-term health and environmental consequences of energy use and development, receives the largest proportion of the funds.

[2]For requested versus actual appropriations, the years 1981 to 1990 are used because of the unavailability of earlier data.

Funding in actual year dollars for magnetic fusion, which seeks to establish the scientific and technological base required for the production of magnetic fusion energy, was $350.3 million in fiscal year 1980 and $320.3 million in fiscal year 1990—a decrease of 8.6 percent. However, adjusted for inflation, funding decreased almost 42 percent. Between 1980 and 1990, funding rose to a high of $468.4 million in fiscal year 1984. The difference in requested and actual appropriations ranged from 12.5 percent less than requested in fiscal year 1985 to 3.2 percent more than requested in fiscal year 1983.

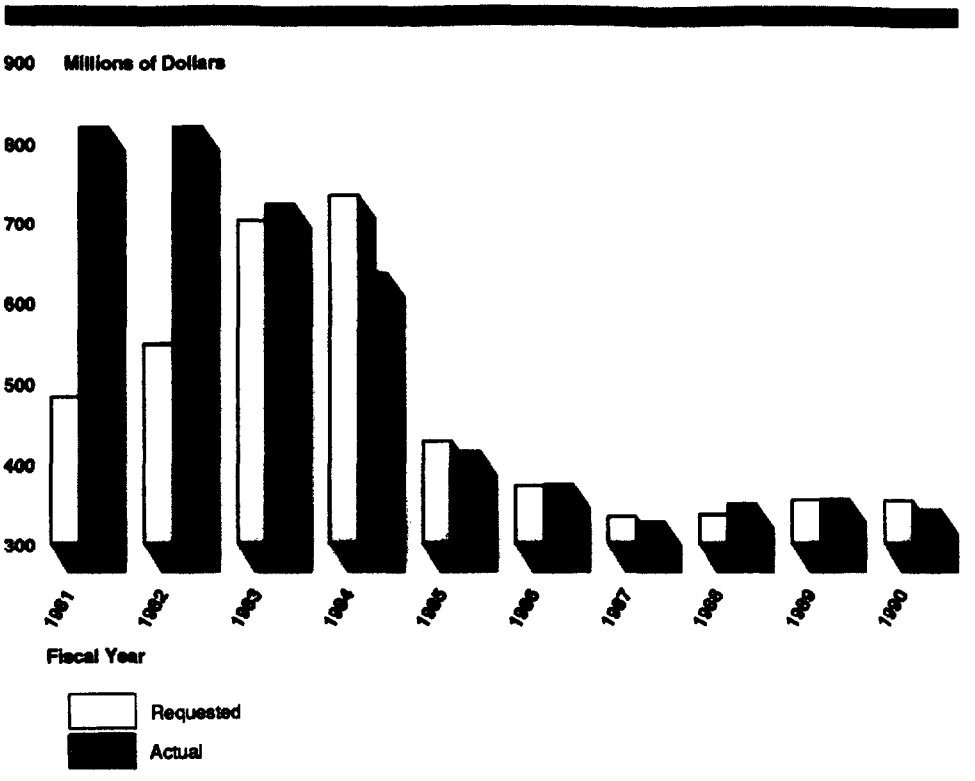
Energy Technologies

Specific energy technologies include nuclear, fossil, conservation, and renewables R&D. Following administration policy of funding only long-term, high-risk research, total funding in these areas, in actual dollars, declined about 46 percent from $3.1 billion in fiscal year 1980 to $1.6 billion in fiscal year 1990. Adjusted for inflation, the decline was almost 66 percent.

Nuclear Energy R&D

Funding for Nuclear Energy R&D, in actual dollars, declined 68 percent from $1.1 billion in fiscal year 1980 to $341.8 million in fiscal year 1990. Adjusted for inflation, the decline was almost 80 percent. During this period funding for developing the Clinch River breeder reactor was terminated. Nuclear Energy R&D includes research in, among other things, light water reactors, advanced reactors, and nuclear facilities. The Light Water Reactor program supports industry-led efforts to revitalize and advance the light water reactor technology. The Advanced Reactor Research and Development program supports development of highly innovative reactor systems with the potential for breakthroughs in economics, safety, licensability, and waste management options. Nuclear energy facilities are to provide safe, reliable, and economical testing capabilities for the development and verification of nuclear power systems for space and defense power systems and civilian applications. After fiscal year 1983, requested funds ranged within less than 1 percent to about 15 percent of actual appropriations. Figure 3.4 shows this difference in dollars. The difference in actual versus requested appropriations for fiscal years 1981 and 1982 was attributable to funding for the breeder reactor program.

Figure 3.4: Requested Versus Actual Appropriations for Nuclear Energy R&D for Fiscal Years 1981 to 1990



Fossil Energy R&D

Funding for Fossil R&D declined 51 percent in actual dollars from $847.4 million in fiscal year 1980 to $418.3 million in fiscal year 1990, not including Clean Coal Technology.[3] Adjusted for inflation, funding declined almost 69 percent. Coal research programs supported R&D on technologies to expand coal utilization in an environmentally sound manner. Petroleum research concentrates on enhanced recovery of light and heavy oils. The Gas program assists the private sector in developing cost-effective diagnostic and extraction technologies which are required to produce gas efficiently and economically from unconventional gas resources. Funding in each area of Fossil R&D declined as shown in table 3.1.

[3]Clean Coal Technology was funded at $1.2 billion from fiscal year 1986 to 1990. These funds are separate from Fossil Energy's Coal program funds. The Clean Coal Technology program provides financial assistance to industry to demonstrate the commercial applications of emerging technologies that would enhance the use of coal but in both a more efficient and environmentally acceptable manner.

Table 3.1: Change in Fossil R&D Funding From Fiscal Years 1980 to 1990

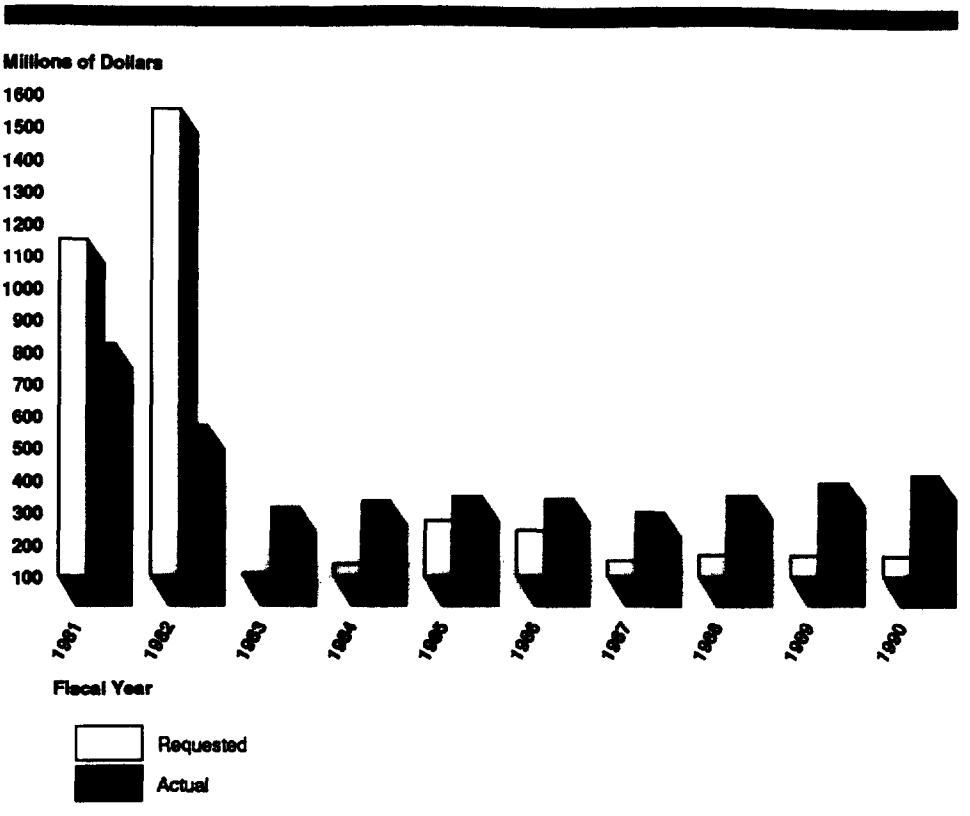
Actual year dollars in millions

Program	1980	1990	Percent change
Coal	$754.9	$275.3	−63.5
Gas	30.7	14.4	−53.1
Petroleum	61.7	39.9	−35.3
Other Fossil	[a]	88.7	

[a]Appropriations for "Other Fossil" in fiscal year 1980 were included under the coal, petroleum, and gas programs.

As shown in figure 3.5, from fiscal years 1983 through 1990, DOE requests were less than actual appropriations for Fossil R&D. These requested budgets reflected DOE's policy that it would withdraw federal support from near-term development and demonstration programs which could and should be carried forward by private industry. DOE stated that government research funding could then be directed toward solving fundamental problems and toward generic research in such areas as advanced coal cleaning, coal conversion, and enhanced oil recovery.

Figure 3.5: Requested Versus Actual Appropriations for Fossil Energy R&D for Fiscal Years 1981 to 1990



Conservation R&D

Conservation R&D's budget in actual dollars decreased over 34 percent from fiscal year 1980 to fiscal year 1990. Adjusted for inflation, Conservation's R&D budget decreased over 58 percent. Conservation R&D includes buildings and community systems, industry, transportation, and multi-sector. The Buildings and Community Systems program supports generic research in building systems, with the goal of encouraging optimal energy use in new and retrofitted structures. The Industry program supports research and development of technologies in such areas as waste energy reduction and improved process efficiency which have the potential to increase energy use efficiency in private industry. The Transportation program focuses on research to improve the energy efficiency of vehicle systems. The Multi-Sector program supports basic research and exploratory development of new concepts that offer increased efficiencies in energy conversion and utilization. Table 3.2 shows the decrease for each area funded under Conservation R&D.

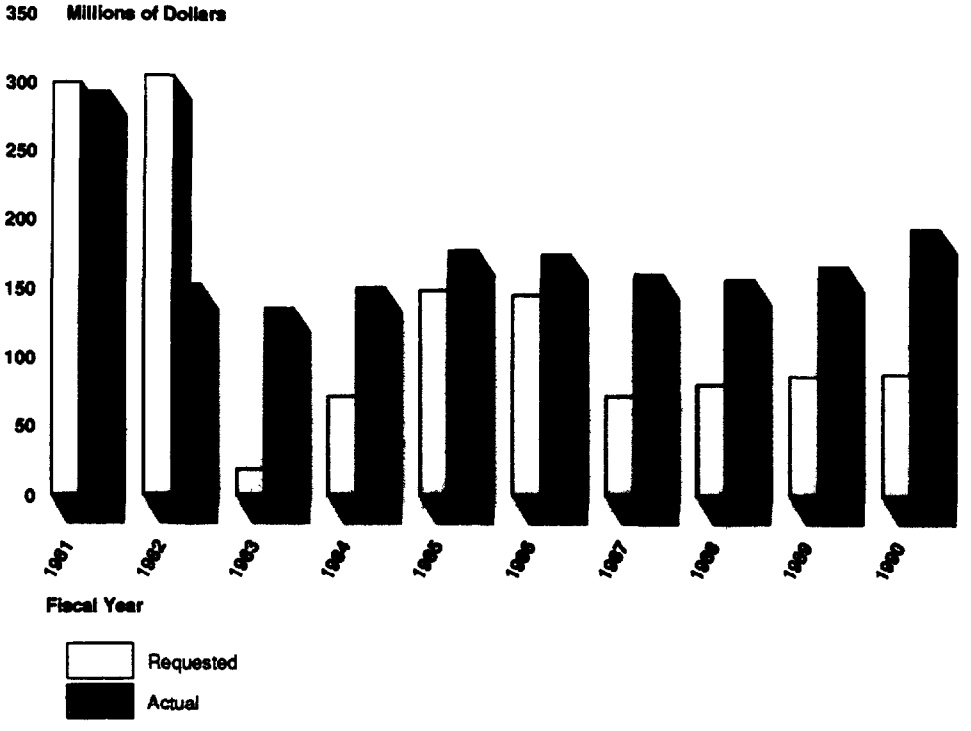
Table 3.2: Change in Conservation R&D Funding From Fiscal Years 1980 to 1990

Actual year dollars in millions

Program	1980	1990	Percent change
Transportation	$113.4	$65.0	−42.7
Industrial	60.2	50.9	−15.4
Buildings and Community Systems	104.4	38.8	−62.8
Multi-Sector	16.8	36.0	114.3

As shown in figure 3.6, Conservation R&D requested budgets were less than actual budgets for fiscal years 1983 through 1990. For fiscal year 1983, the requested budget for Transportation, Industrial, and Buildings and Community Systems was zero, which was in keeping with the previous administration's policy to withdraw support from technology programs where sufficient market incentives existed, i.e., consumer products, advanced automotive engine development, demonstration of electric and hybrid vehicles, and industrial process efficiency. Although funds were appropriated for these areas, the funding was at reduced levels from fiscal years 1981 to 1982.

Figure 3.6: Requested Versus Actual Appropriations for Conservation R&D for Fiscal Years 1981 to 1990



Solar and Renewable Energy R&D

The budget for Solar and Renewable Energy R&D decreased in actual dollars over 83 percent from 1980 to 1990. The Solar Energy program supports generic and long-range research in photovoltaics, biofuels, wind, solar thermal and solar building technologies. Renewable Energy R&D includes geothermal, electric energy systems, and electric storage systems. Geothermal Energy research programs support research in energy from geothermal resources. Electric energy systems directs research toward solving mid- to long-term problems in electric energy transmission and distribution and integrating renewable energy resources into the utility network. Energy storage systems supports generic research into electrochemistry and applied battery research into a variety of specific battery types. Table 3.3 shows the decrease in funding from 1980 to 1990 for Solar and Renewable Energy R&D.

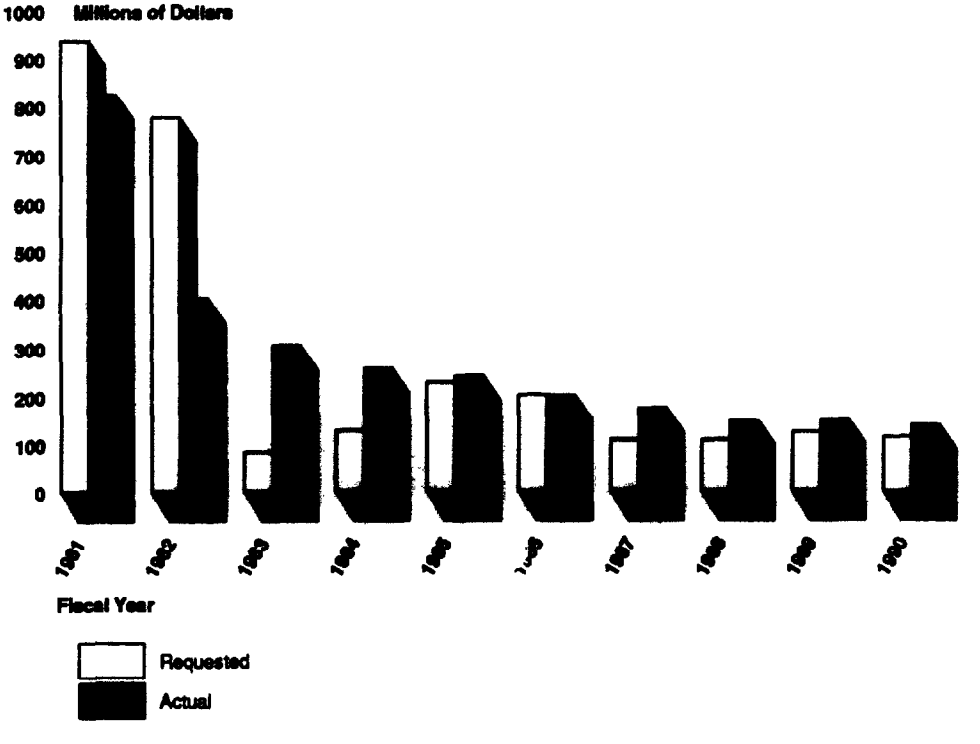
Table 3.3: Change in Solar and Renewable Energy R&D Funding From Fiscal Years 1980 to 1990

Actual year dollars in millions

Program	1980	1990	Percent change
Solar Energy	$559.2	$89.7	−84.0
Renewables	273.5	48.0	−82.5

As shown in figure 3.7, from fiscal year 1983 to 1990, except for fiscal year 1986, requested funds were consistently less than actual appropriations, which was in keeping with the previous administration's policy that the overall objective of the Solar and Renewable programs was to contribute scientific and engineering knowledge to the renewable energy technology base so that industry could develop systems for transforming renewable resources into energy forms suitable for widespread application.

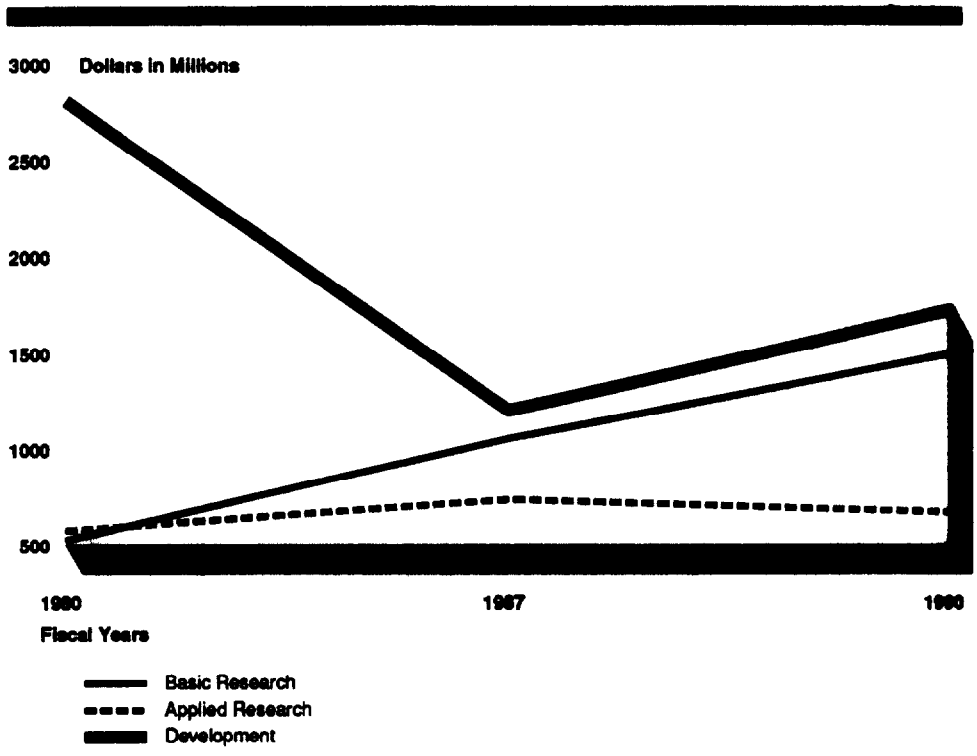
Figure 3.7: Requested Versus Actual Appropriations for Renewable Energy R&D for Fiscal Years 1981 to 1990



Distribution of Basic, Applied, and Developmental Research

From fiscal year 1980 through 1990, DOE's civilian energy R&D funds for basic research have generally increased while funds for applied research have increased slightly and funds for development have generally decreased significantly.[1] Figure 4.1 shows these changes. In addition, as shown in figures 4.2 and 4.3, basic research's share of the R&D pie has grown from 13 percent in fiscal year 1980 to 39 percent in fiscal year 1990. At the same time, from fiscal year 1980 to 1990, the Office of Defense Programs applied research budget increased 88.9 percent from $178.2 million to $336.7 million and its development budget increased 124.4 percent from $713.6 million to $1.6 billion.

Figure 4.1: Funding for Basic and Applied Research and Development From Fiscal Years 1980 to 1990



[1] All funds are in actual dollars.

Figure 4.2: Percent of Total Energy R&D Budget for Basic, Applied, and Development—Fiscal Year 1980

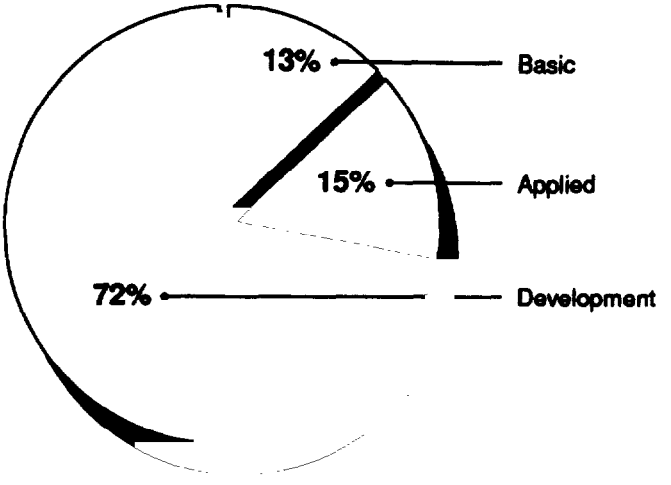
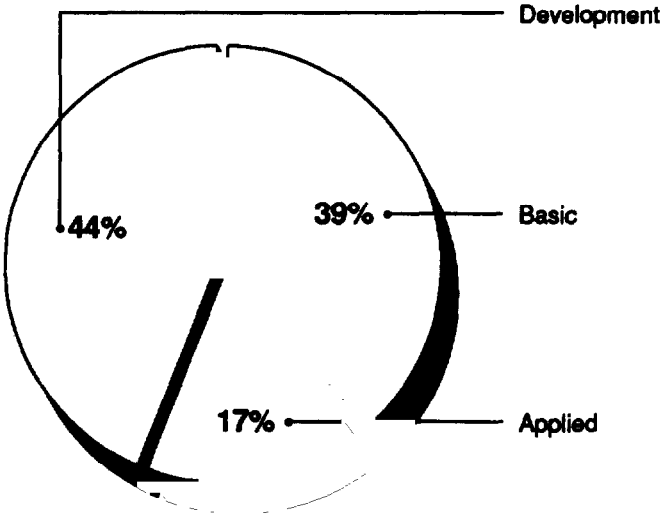


Figure 4.3: Percent of Total Energy R&D Budget for Basic, Applied, and Development—Fiscal Year 1990



Basic Research

DOE's total civilian basic research budget from fiscal year 1980 through 1990 was $10.4 billion. As shown in figure 4.4, from 1980 to 1990, DOE's total basic research budget increased 186.5 percent, from $522.4 million to $1.5 billion, due in large part to a 173-percent increase in the Office of Energy Research's (OER) budget. Figure 4.5 shows a breakout of the total basic research budget by program area.

Figure 4.4: Basic Research Budget for Fiscal Years 1980 Through 1990

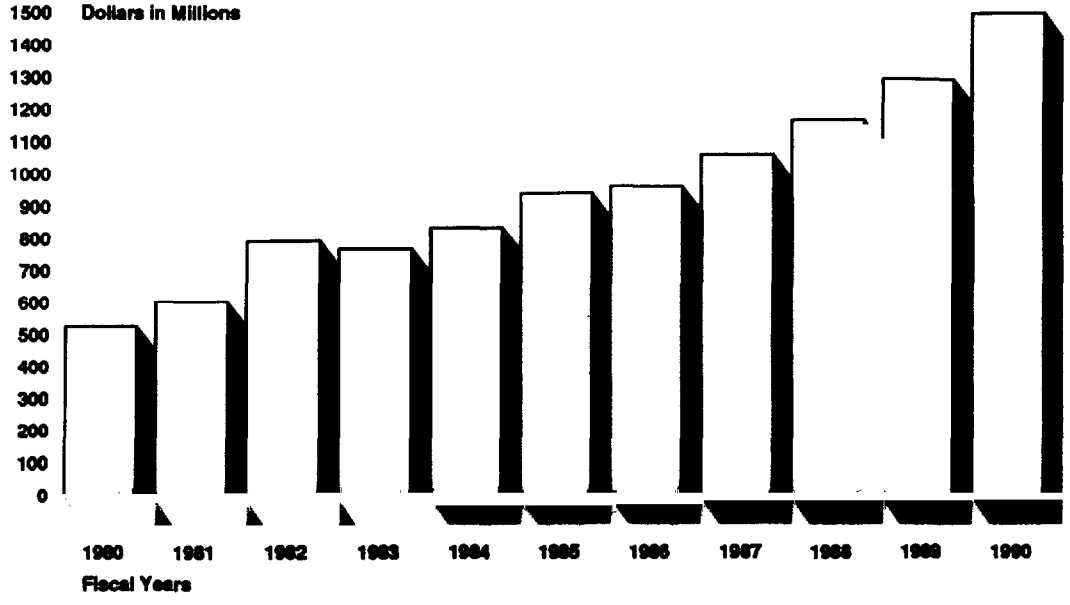
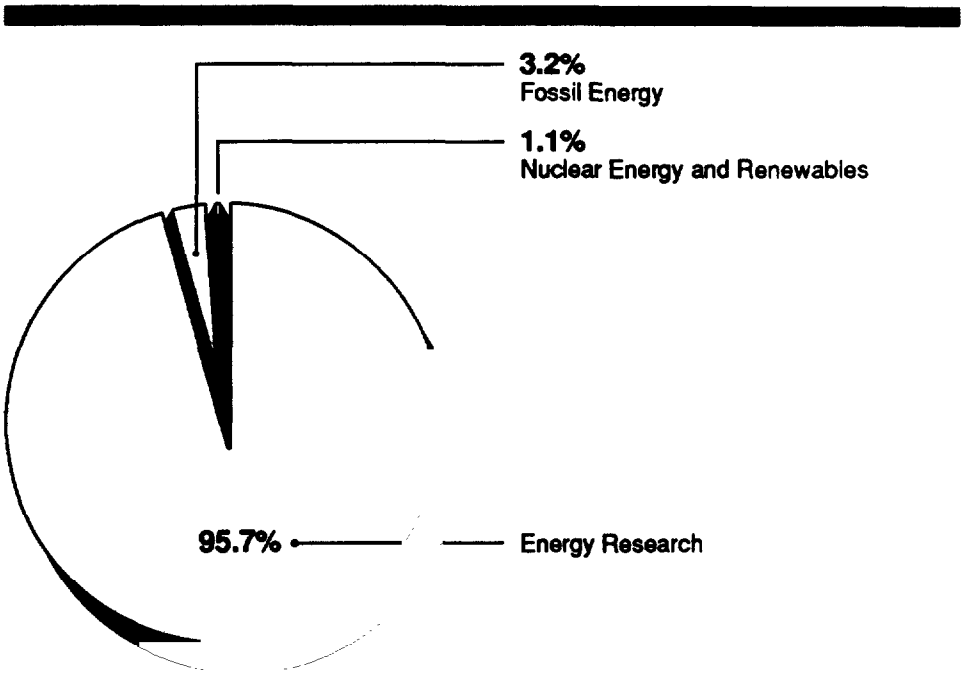


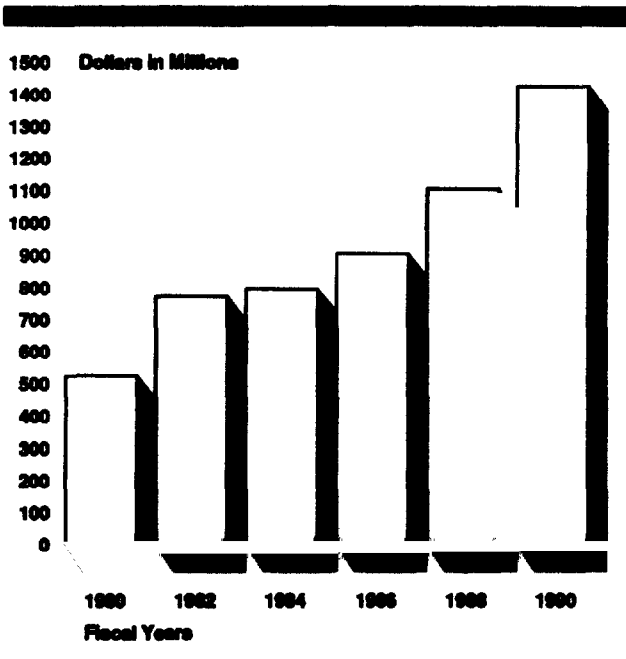
Figure 4.5: Program Area Share of Basic Research Budget—Fiscal Years 1980 Through 1990



Office of Energy Research

From fiscal year 1980 through 1990, OER received an average of 95.7 percent of DOE's basic research money. These funds have been concentrated in High Energy Physics, Nuclear Physics, and Basic Energy Sciences programs. OER received a total budget of $9.9 billion during this period, of which $3.9 billion was for High Energy Physics, $3.5 billion was for Basic Energy Sciences, and $1.6 billion was for Nuclear Physics. As shown in figure 4.6, the Office of Energy Research's basic research budget has increased 173 percent from $519.8 million in fiscal year 1980 to $1.4 billion in fiscal year 1990. This increase was due to a steady rise in funding for High Energy Physics, Nuclear Physics, and Basic Energy Sciences.

Figure 4.6: Office of Energy Research Basic Research Budget



Office of Fossil Energy

The Office of Fossil Energy received an average of 3.2 percent of DOE's basic research budget from fiscal year 1980 through 1990. Its budget increased from $.6 million in fiscal year 1980 to $62.8 million in fiscal year 1990, an almost 105-fold increase, due to increases in the Coal program. Of Fossil's total basic research budget from fiscal year 1980 to 1989 of $300.9 million, $265.2 million was concentrated in the Coal program.[2]

[2]Data for fiscal year 1990 was not broken out for the Coal program.

Offices of Nuclear Energy and Conservation and Renewables

From fiscal year 1980 through 1990, the Offices of Nuclear Energy and Conservation and Renewables received an average total of 1.1 percent of DOE's basic research budget. Nuclear Energy's budget dropped from $2.0 million in fiscal year 1980 to $0 in fiscal year 1986 and has remained at $0 through 1990. Renewables increased from $0 in fiscal year 1980 to $21.5 million in fiscal year 1986 and generally remained steady until it dropped to $14.8 million in fiscal year 1990. Conservation R&D received no basic research money from fiscal year 1980 through 1990.

Applied Research

DOE's total civilian applied research budget from fiscal year 1980 through 1990 was $9.2 billion. As shown by figures 4.7 and 4.8, DOE's total civilian applied research budget fluctuated. It increased 109.8 percent from fiscal year 1980 to 1983 mainly because of increases in OER's Magnetic Fusion program and Fossil Energy's Coal program. In addition, Nuclear Energy's Naval Reactors applied research program was funded only in fiscal years 1983 and 1985 which resulted in a decrease in applied research in general of 23.9 percent in fiscal year 1984 and an increase of 47.3 percent in fiscal year 1985. Applied research funding decreased 50.3 percent from fiscal year 1985 to 1990 primarily because of decreases in OER's Magnetic Fusion program and in Renewable Energy's Solar Energy program. Figure 4.9 shows a break out of the applied research budget by program area.

Figure 4.7: Applied Research Budget

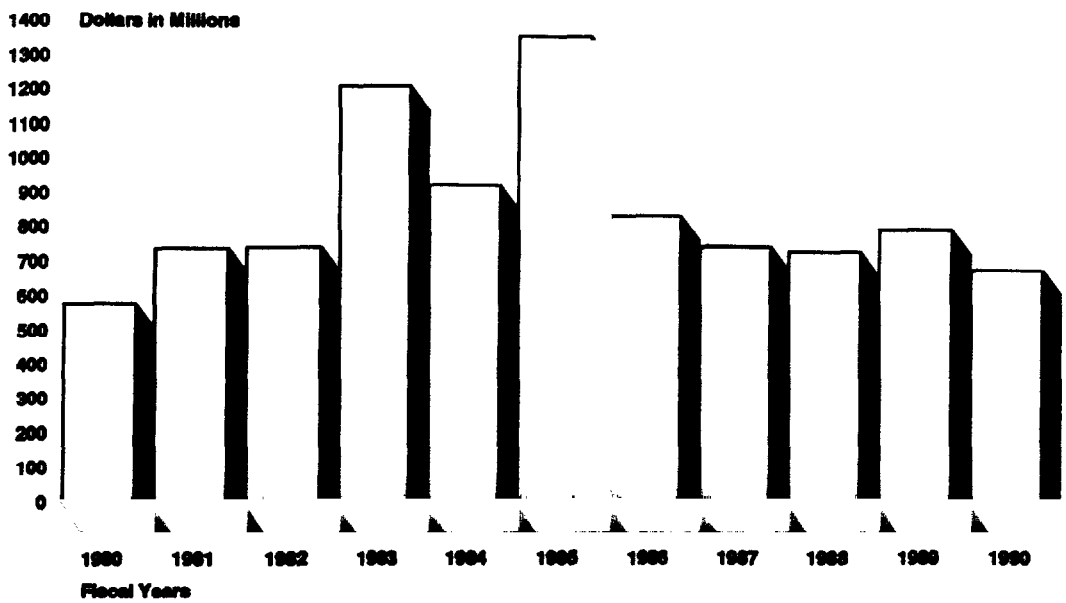


Figure 4.8: Applied Research Funding by Program Area

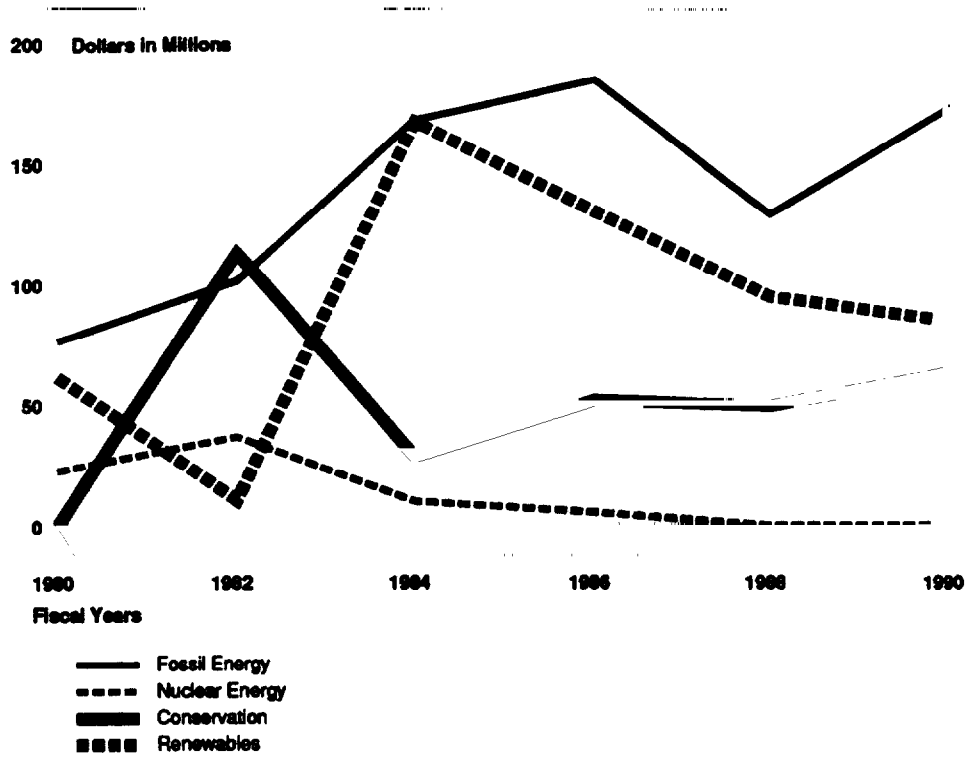
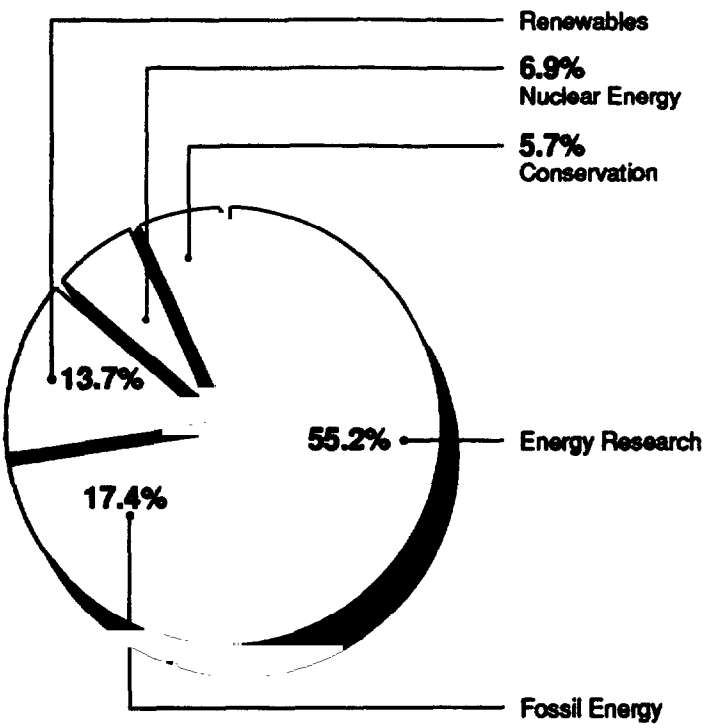


Figure 4.9: Program Area Share of Applied Research Budget—Fiscal Years 1980 Through 1990



Note: Applied budget totals 99% due to rounding.

Office of Energy Research

The Office of Energy Research received an average of 55.2 percent of DOE's applied research money from fiscal year 1980 through 1990. OER's applied research budget increased 53.8 percent from fiscal year 1980 to 1984 from $351.4 million to $540.6 million and decreased 33.3 percent from fiscal year 1985 to 1990 from $521.1 million to $347.7 million. From fiscal year 1980 through 1990, $1.5 billion of OER's applied research budget of $4.9 billion was concentrated in biological and environmental research and $3.3 billion was in magnetic fusion.

Office of Conservation and Renewables

From fiscal year 1980 through 1990, the Office of Conservation and Renewables received an average of 19.4 percent of DOE's applied research funds. Renewables made up 13.7 percent of the applied research budget, with the Solar program accounting for an average of almost 76 percent of the Renewables' budget from fiscal year 1980 to 1990. Conservation R&D made up an average of 5.7 percent of the applied research budget from fiscal year 1980 to 1990. In fiscal years

1981 and 1985, the office's total applied research budget peaked primarily due to an increase in Solar Energy program funding. From fiscal year 1985 to 1990, the office's total budget decreased 31.1 percent primarily because of decreases in the Solar Energy program.

Office of Fossil Energy

The Office of Fossil Energy received an average of 17.4 percent of DOE's applied research money from fiscal year 1980 through 1990. Fossil's budget increased 145.5 percent from $76.2 million in fiscal year 1980 to $187.1 million in fiscal year 1985. Fossil's budget then decreased 35.6 percent to $120.4 million in 1987. From fiscal year 1988 to 1990, Fossil's budget increased 33.9 percent from $129.2 million to $173 million. From fiscal year 1980 to 1989, 82 percent of Fossil's research budget was concentrated in the Coal program.[3]

Office of Nuclear Energy

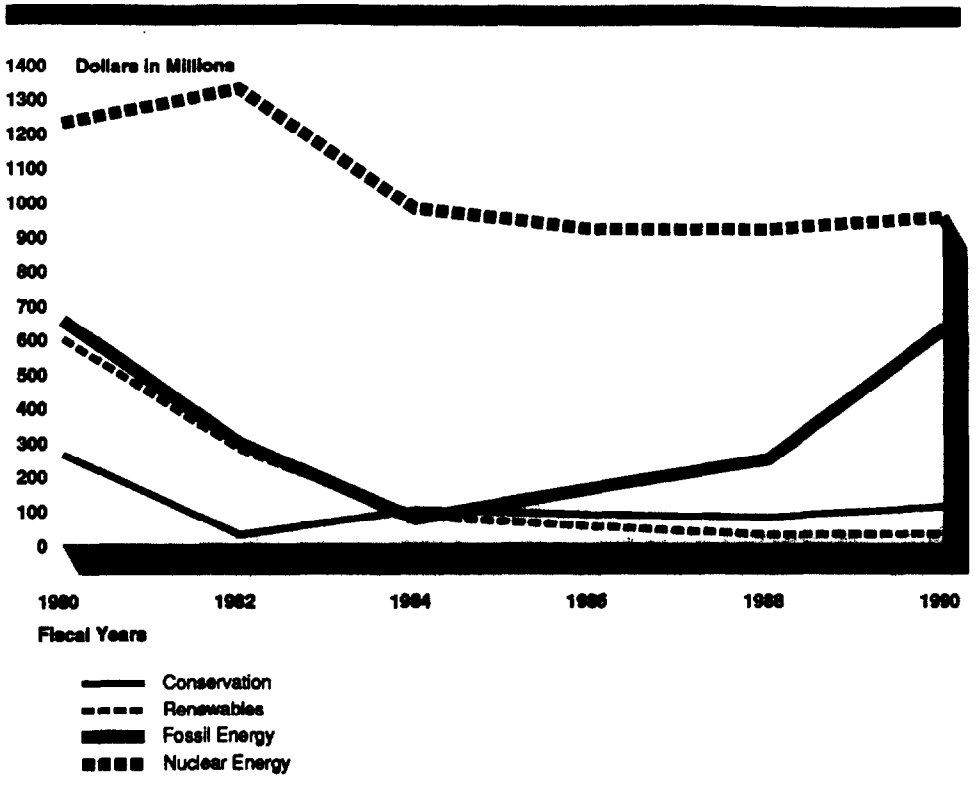
From fiscal year 1980 through 1990, the Office of Nuclear Energy received an average of 6.9 percent of DOE's applied research budget. This average reflects the fact that from 1987 to 1990 the Office of Nuclear Energy received no applied research money. Nuclear Energy received a total of $885.2 million in applied funds of which $732.2 million was for naval reactors.

Development

DOE's total civilian development budget from fiscal years 1980 through 1990 was $17.1 billion. DOE's total development budget decreased 72.9 percent from $2.8 billion in fiscal year 1980 to $760.9 million for fiscal year 1985. As illustrated in figure 4.10, these decreases are attributable largely to decreases in the Conservation and Renewables, Fossil, and Nuclear Energy program areas. From fiscal year 1985 to 1990, the development budget increased 126.1 percent from $760.9 million to $1.7 billion. The increases occurred in Fossil's Clean Coal Technology program and Nuclear Energy's Naval Reactors program.

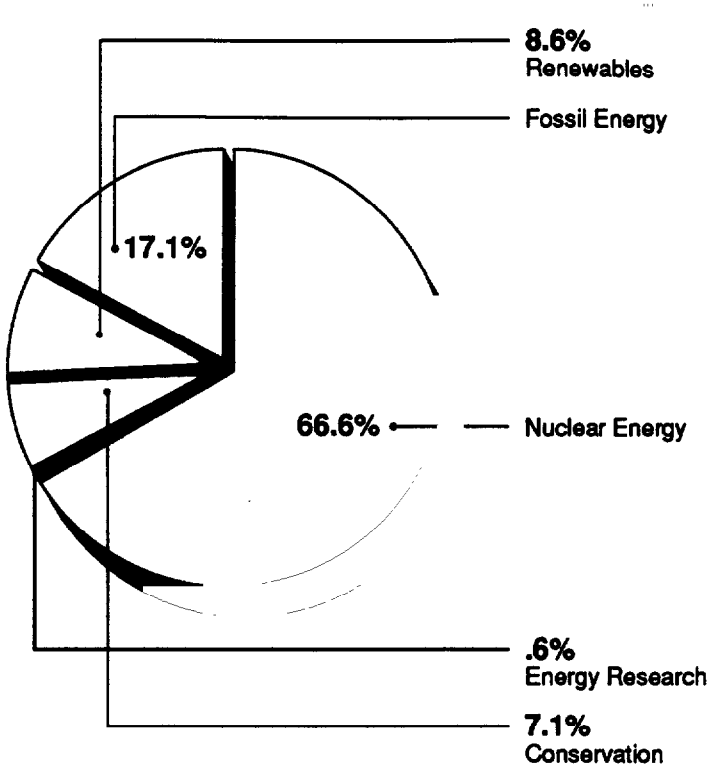
[3]Data for fiscal year 1990 was not broken out for the Coal program.

Figure 4.10: Development Research Funding by Program Area



Development research generally had the highest total research budget from fiscal year 1980 to 1990. Figure 4.11 shows a breakout of the total development budget by program area.

Figure 4.11: Program Area Share of Development Research Budget—Fiscal Years 1980 Through 1990



Office of Nuclear Energy

From fiscal year 1980 through 1990, the Office of Nuclear Energy received an average of 66.6 percent of DOE's development budget. Nuclear Energy's budget decreased 22.5 percent from $1.2 billion in 1980 to $952.8 million in 1990. This can be attributed to a 58.1-percent decrease in the Nuclear Energy R&D program and a 100-percent decrease in the Remedial Action and Waste Technology program.

Office of Conservation and Renewables

The Office of Conservation and Renewables received an average of 15.8 percent of DOE's development funds from fiscal year 1980 through 1990. Renewables R&D accounted for an average of 8.6 percent of the development budget, and Conservation R&D accounted for an average of 7.1 percent of the development budget. From fiscal year 1980 to 1989, the Office of Conservation and Renewables' budget dropped 88.5 percent from $860.1 million to $99.1 million. This was attributable to a 71.2-percent reduction in Conservation R&D from $262.1 million to $75.6 million, a 92.7-percent reduction in the Geothermal program, and a 98.8-

percent reduction in the Solar Energy program. In fiscal year 1990 the Office of Conservation and Renewables budget increased 39.2 percent from 1989 due to a 43.9-percent increase in the Conservation R&D program.

Office of Fossil Energy

The Office of Fossil Energy received an average of 17.1 percent of DOE's development funds from fiscal year 1980 through 1990. From fiscal year 1980 to 1985, Fossil Energy's total development budget decreased 89.2 percent from $652.1 million to $70.2 million. This was primarily due to a decrease in the Coal program from $579.1 million to $60.1 million. However, from fiscal year 1986 to 1990, Fossil's budget increased 288 percent from $161.8 million to $628.4 million, primarily due to the Clean Coal Technology program which was first funded in 1986.

Office of Energy Research

The Office of Energy Research received an average of .6 percent of the development budget. From fiscal year 1980 to 1990, the budget decreased 97.9 percent from $61.1 million to $1.3 million due to the elimination of development funding for the Magnetic Fusion program from 1982 to 1990.

DOE's Major Demonstration Projects

From the mid-1970s through 1990, DOE invested a total of $6.0 billion in major demonstration projects.[1] Demonstration projects are defined as the evaluation and verification of large scale energy systems in operational circumstances for their commercial application. Table 5.1 summarizes the number, cost, and status of DOE's major demonstration projects by program area. See appendix I for a detailed list of the major demonstration projects.

Table 5.1: Summary by Program Area of DOE Major Demonstration Project Activity

Dollars in millions

	Projects terminated		Projects completed		Projects ongoing		
Program	**No.**	**Amount**	**No.**	**Amount**	**No.**	**Amount**	**Total**
Conservation	3[a]	$115.1	2[b]	$151.4			$266.5
Nuclear	1[c]	1,600.0			1	$949.3	2,549.3
Fossil	9[d]	495.4	7[e]	2,213.0			2,708.4
Clean Coal	2[f]	4.2			16	486.7	490.9[g]
Total	**15**	**$2,214.7**	**9**	**$2,364.4**	**17**	**$1,436.0**	**$6,015.1**

[a]A Conservation official defined a terminated project as a project that was aborted, usually without fully achieving its goals and objectives. The Wind Energy Demonstration - Field Evaluation Program was terminated because of the prior administration's policies. The Heber and Baca Geothermal Demonstration Projects were terminated because of production problems.

[b]A Conservation program official defined a completed project as a project that was continued to its planned completion date.

[c]The Clinch River Breeder Reactor was terminated by the Congress in fiscal year 1984.

[d]A Fossil Energy official defined a terminated demonstration project as a project that is stopped because of a change in level of appropriations available, mission need, program objectives or project goals or unsatisfactory performance towards established goals. Two Coal Liquefaction and seven Surface Coal Gasification Projects were terminated prior to construction because of the prior administration's policies.

[e]A Fossil Energy official defined a completed demonstration project as the design, construction, testing, operation and evaluation of nearer to full scale modules under conditions more approximating commercial permitting and operations.

[f]The Underground Coal Gasification Project and the Advanced Coal Gasification Combined Cycle Power Generation Plant were terminated because industry sponsors were unable to obtain financing. The indicated funding was obligated, but no additional funds will be spent.

[g]This total does not include the eight clean coal projects under negotiation, totaling $252.1 million.

[1]This total does not include eight clean coal projects which are under negotiation as of Feb. 14, 1990.

Objective, Scope, and Methodology

The objective of this assignment was to determine how DOE allocates applied R&D funds. We were asked specifically:

(1) How does DOE prioritize funding requests among the various research and development areas? What are the underlying criteria and philosophy for such decisions? (See section 2.)

(2) To what extent does DOE coordinate its R&D agenda among participating internal DOE organizations? (See section 2.)

(3) What role, if any, do the Office of Management and Budget and the various advisory groups play in allocating funds among DOE research programs? (See section 2.)

(4) How have DOE priorities evolved over the past 10 years? (See section 3.)

(5) How has the overall DOE funding for R&D been distributed between fundamental or basic research and applied or project oriented research, development and demonstration? In energy R&D has there been a change in emphasis from applied R&D to basic research over the past decade? (See section 4.)

(6) How much has DOE invested in major demonstration projects over the past 10 years? How many of these projects have been terminated before completion, and what was the basis or criteria for the termination? (See section 5.)

To answer these questions, we spoke with cognizant agency officials in DOE's budget office and assistant secretary-level offices to determine their processes for planning and allocating energy R&D funds for the period 1980 to 1990. In addition, we obtained pertinent DOE orders and memoranda concerning the allocation process. We also examined DOE policy plans for the years in which they were available—1981, 1983, 1985, and 1987—to determine what guidance DOE issued on its priorities for energy R&D. DOE also provided appropriation history data for its R&D programs which we used to determine trends in research areas over the period fiscal year 1980 to 1990. Because of time constraints, we did not verify this data. To provide a clearer comparison of appropriations over time, we adjusted the dollar amounts to account for the effects of inflation. We also spoke with OMB officials concerning their role in the allocation process and obtained OMB guidance on the energy R&D budget process. We spoke with the executive director of the Energy Research

Advisory Board and a representative of the National Petroleum Council and the National Coal Council to determine what role they play in the R&D allocation process. We also examined 1981, 1983, and 1985 ERAB reports for their recommendations on the allocation of R&D funds. For the 1985 report we analyzed several recommendations for DOE actions. We did not analyze every recommendation due to time constraints and the voluminous nature of the ERAB report.

DOE provided data on the distribution of funds for basic, applied, and development research for the period 1980 to 1990 by program office. The data for 1980 to 1989 was dated January 1989 and the 1990 data was dated January 1990. Due to time constraints, we did not independently verify the data.

We conducted our review from September 1989 to February 1990 in accordance with generally accepted government auditing standards.

We discussed the draft report with cognizant DOE officials. They generally agreed with its contents.

DOE Major Demonstration Projects

Dollars in millions

Program area/project	Start/end date[a]	Status[b]	Basis for termination	DOE cost
Conservation				
Heber Geothermal Demonstration Project	9/80 7/87	Terminated. Negotiations in progress to sell plant which will lead to government recuperation of part of its investment.	Insufficient reservoir production.	$64.5
Baca Geothermal Demonstration Project	9/78 1982	Terminated by DOE, UNOCAL, and Public Service of New Mexico. DOE awaiting final payments from powerplant equipment sales.	Only one half of the necessary steam was available from the drilled wells.	$47.0
Barstow Solar Thermal Demonstration Project	9/77 9/88	Completed.	[c]	$140.0
Field Evaluation Program Wind Energy Demonstration Project	1979 1981	Terminated. Reports published.	Prior administration's policy.	$3.6
Slow Speed Diesel Cogeneration System	9/79 6/84	Completed. Four major units sold and operating.	[c]	$11.4
Nuclear				
Clinch River Breeder Reactor Project	1973 FY 1984	Terminated.	Congress eliminated funding.	$1,600.0
Atomic Vapor Laser Isotope Separation Program	1972	Ongoing.	[c]	$949.3
Fossil				
Solvent Refined Coal Demo Plant I	3rd Quarter FY 1978 8/84	Terminated prior to construction.	Prior administration's policy.	$190.7
Solvent Refined Coal Demo Plant II	3rd Quarter FY 1978 7/81	Terminated prior to construction.	Prior administration's policy.	$70.8
High BTU "A"	10/75 7/81	Terminated prior to construction.	Prior administration's policy.	$53.7
High BTU "B"	10/75 7/81	Terminated prior to construction.	Prior administration's policy.	$77.8
Low/Med BTU Fuel Gas Industrial	FY 1976 2/83	Terminated prior to construction.	Prior administration's policy.	$11.7
Low/Med Industrial BTU "A"	FY 1976 7/81	Terminated prior to construction.	Prior administration's policy.	$65.6
Low-BTU Fuel Gas Utility	9/80 2/81	Terminated prior to construction.	Prior administration's policy.	$7.8
Low-BTU Fuel Gas-Small Industry	FY 1979 FY 1979	Terminated prior to construction.	Prior administration's policy.	$17.3
Low-BTU Fuel Gas -Utility B	FY 1981 FY 1981	Terminated prior to construction.	Prior administration's policy.	Not available
Ft. Lewis Pilot Plant	FY 1975 7/81	Completed. No longer needed to support Solvent Refined Coal demonstration project.	[c]	$20.0

Program area/project	Start/end date[a]	Status[b]	Basis for termination	DOE cost
H-Coal Pilot Plant	12/77 9/82	Completed. Successfully demonstrated plant operability using ILL. #6 and Wyodak Coal.	[c]	$277.9
EXXON Donor Solvent Pilot Plant	1/76 12/85	Completed. Successfully demonstrated plant operability with 3 coals.	[c]	$163.3
Methanol Conversion Pilot Plant	3/80 3/86	Completed. Operation successfully completed, plant dismantled.	[c]	$11.2
BI-Gas Pilot Plant	FY 1972 12/82	Completed. General Services Administration sold facility.	[c]	$113.6
HY-Gas Pilot Plant	7/77 12/80	Completed. Turned over to Institute of Gas Technology, then mothballed.	[c]	$72.1
Great Plains Coal Gasification Project	FY 1982 10/88	Completed. Sponsors defaulted on government loan guarantee. Government operated plant until sold 10/31/88.	[c]	$1,555.0
Clean coal program				
Round 1				
Pressurized Fluidized Bed Combuster	2/87	Ongoing.	[c]	$60.2
Circulating Atmospheric Fluidized Bed	8/88	Ongoing.	[c]	$19.9
Circulating Atmospheric Fluidized Bed		Under negotiation.	[c]	$65.0
Underground Coal Gasification		Terminated.	Energy Intl could not obtain financing.[d]	$3.3
Integrated Gasification Combined Cycle		Terminated.	M.W. Kellogg could not obtain financing.[d]	$.9
Limestone Injection Multistage Burner	6/87	Ongoing.	[c]	$7.6
Advanced Cyclone Combuster	2/87	Ongoing.	[c]	$.5
Gas Reburning and Sorbent Injection	7/87	Ongoing.	[c]	$14.9
Prototype Commercial Coal/Oil Co-Processing Plant	12/87	Ongoing.	[c]	$45.0
Advanced Slagging Combustor	11/88	Ongoing.	[c]	$23.5
Advanced Coal Cleaning Process		Under negotiation.	[c]	$28.0
Advanced Coal Cleaning Process		Under negotiation.	[c]	$7.7
Round 2				
Integrated Gasification Combined Cycle Repowering		Under negotiation.	[c]	$129.4
Philip Sporn Pressurized Fluidized-Bed Combustor	4/90	Ongoing.	[c]	$184.8
WSA-SNOX Flue Cleaning Demo.	12/89	Ongoing.	[c]	$15.7
Sox-Nox-Rox-Box Flue Gas Cleaning Demo.	12/89	Ongoing.	[c]	$4.9

(continued)

Program area/project	Start/end date[a]	Status[b]	Basis for termination	DOE cost
LNS Burner for Cyclone Fired Boilers		Under negotiation.	[c]	$6.8
CT 121 Flue Gas Disulfurization	4/90	Ongoing.	[c]	$17.5
Advanced On-site Flue Gas Disulfurization	12/89	Ongoing.	[c]	$63.4
Limestone Scrubber Cement Kiln Gas Cleaning	12/89	Ongoing.	[c]	$4.8
Coke Oven Gas Cleaning	11/89	Ongoing.	[c]	$13.5
Otisca Fuel Demo Project		Under negotiation.	[c]	$3.5
Advanced Wall-Fired Combustion	12/89	Ongoing.	[c]	$5.2
Selective Catalytic Reduction		Under negotiation.	[c]	$7.5
Advanced Tang.-Fired Combustion		Under negotiation.	[c]	$4.2
Coal Reburning in Cyclone-Fired Boilers	4/90	Ongoing.	[c]	$5.1

[a]Dates are as provided by DOE.

[b]See table 5.1 for definitions of terminated and completed projects.

[c]Not applicable.

[d]The indicated funding has been obligated and no additional funding will be spent.

Major Contributors to This Briefing Report

Resources, Community, and Economic Development Division, Washington, D.C.

Judy England-Joseph, Associate Director
Robert E. Allen, Jr., Assistant Director
Edward E. Young, Assignment Manager
Ilene Pollack, Evaluator-in-Charge
Elise Bornstein, Evaluator

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